ILLUMINATING ENGINEERING

NOVEMBER 1952

Illumination at a Point from Round Tubular Sources
Visual Data for Specifying Illumination
Inter-Region Lighting Contest Winners
Submarine and Small Vessel Lighting
Rapid-Start Lamp and Ballast Design
Supplementary Lighting

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

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J-04319

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Westinghouse

LIGHTING DIVISION
Edgewater Park, Cleveland, Ohio

INSTALLATION: State Savings Bank, Hartford, Conn.
ARCHITECT: R. B. O'Connor & W. H. Kilham, Jr., New York City, N. Y.
LIGHTING ENGINEERING BY: R. Cooper, Baldwin Stewart Electric Co., Hartford, Conn.
ENGINEER: Kaiser, Muller & Davies, New York City, N. Y.
NEW BANKING AREA: 36'-3" x 48'.
CEILING HEIGHT: 12'.
FIXTURES: Litecontrol No. 9034 3-lamp recessed fixtures, using Holophane No. 9030 and No. 9031 lenses.
LAMPS: Each fixture has two standard cool white, and one de luxe warm white lamp.
SPACING: 6' x 9'.
OVER-ALL INTENSITY: 42 footcandles average in service. On tellers' desk plates, 46 footcandles average in service.
Submitted in contest by: Edward Cole, Hartford Electric Light Co.

1st PRIZE

Prize Lighting Job PAYS DIVIDENDS

. . . at Hartford State Savings Bank

FIVE hundred new depositors selected this light, attractive lobby the *smart* place to do their banking . . . since it was relighted with ingeniously modified *standard* LITECONTROL fixtures. And so did the Connecticut section of the Illuminating Engineering Society, for they awarded it first prize in a recent lighting contest.

Problem here was to illuminate the new banking area (rear with low ceiling) in a modern distinctive manner . . . yet preserve the architectural tone of the old area (front with 24-foot ceiling).

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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

NOVEMBER
1952

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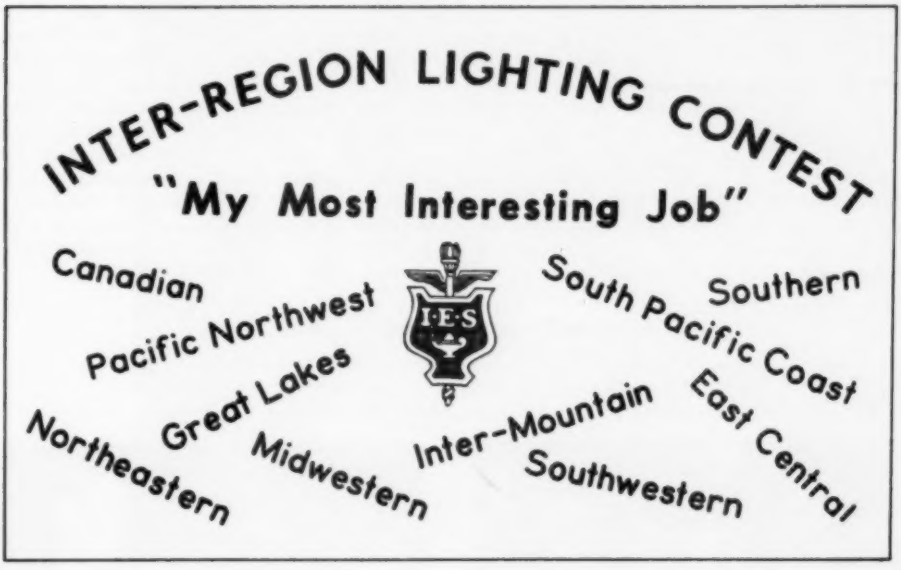

Under the aegis of the I.E.S. Lighting Service Forum, a new important Society project has taken shape this past year — of special significance to I.E.S. members in the lighting application field. For contributions in theory and research in illumination, I.E.S. has ever been acknowledged second to none. Practical lighting contests, however, recognizing and rewarding the contributions of the application engineers and lighting specialists have not previously been undertaken by the Society on a national basis.

In this sense, history was made at the Chicago Conference, September 1952, and the five lighting installations shown on the next several pages represent the first national entries in the first Inter-Regional I.E.S. contest for prize-winning lighting installations. The five entries published are finalists in the fully I.E.S.-sponsored contest, conducted by Sections and Chapters of I.E.S. and Regions of I.E.S. in cooperation with the I.E.S. Lighting Service Forum.

The contest, known locally as "My Most Interesting Lighting Job," offered all I.E.S. members an opportunity to compete with all other members on a national basis. Actually, as set up, the contest was Inter-Regional. Sections and Chapters within a Region conducted contests for the best installation within their Section, in the judgment of an appointed Board of Judges, and under specific rules for scoring. Winners of the local competitions then competed within the Region, for a Regional winner. The five entries on the following pages are Regional winners, who then competed nationally at the Lighting Service Forum session of the National Technical Conference, September 10, 1952.

Rules for judging were quite specific. At each level, judges were given score sheets to appraise each presentation as follows:

Interesting (Is it of unusual interest to the Lighting Application Engineer?)	Excellent 30 Good 20 Fair 10 Poor 0
Application of Engineering Principles (Is this good lighting practice?)	Excellent 30 Good 20 Fair 10 Poor 0
Suitability & Effect of Solution (Did this application fully meet the needs of the user according to Modern Practice?)	Excellent 30 Good 20 Fair 10 Poor 0
Originality of Technique & Practicability of Solution (Is this a new and original solution? Could the same results have been achieved at a lower cost?)	Excellent 30 Good 20 Fair 10 Poor 0
Presentation — Concise, Complete, Clear (Did you understand what the speaker said and showed? Did he hold his audience?)	Excellent 30 Good 20 Fair 10 Poor 0

Judging was taken very seriously at each level; competition was keen, from Section contests up through the Chicago finals.

As operated this year, prizes and rules of the local competitions were set individually by the Sections and Chapters. For the Regional and National contests, rules were drawn up by the Local Activities and Lighting Service Forum Committees, with Paul H. Hildebrand as Regional Co-ordinator and Lee E. Tayler as National Contest Co-ordinator.

In addition to the prizes awarded by the Sections and Chapters, Regional Conference contests awarded a first prize of $25.00, second prize of $15.00 plus honorable mention. At the National Conference, the finalists competed for: first prize—$100.00, second prize—$50.00, third prize—$25.00.

While only seventeen of the Society's fifty-seven Sections and Chapters participated in this first Lighting Service Forum contest for "My Most Interesting Lighting Job," this year the machinery is set up and the way pointed out for full-scale projects in the future. Excellent examples of good lighting practice should not be buried in a file. Local and national recognition, with dissemination as published material and possibly as I.E.S. Lighting Data Sheets, may advance still another Society service to its members and to the public.

Landmarks on the Road to Chicago

Here we see four of the five winners to qualify for the finals at the National Technical Conference in Chicago as they won the "My Most Interesting Lighting Job" sponsored by their Sections and Regions.

FIRST place winner Earl Domoney, far right, holds his prize for winning in the Michigan Section contest. With him are Miss Mary Taepke and Leslie Lyon, other Sectional winners.

SECOND place winner, H. S. James of the Pittsburgh Section, is congratulated by Paul Hildebrand, Vice-President of the East Central Region. Presentation was made at the Regional Conference.

WINNING for the Chicago Section, Carl H. Johnson is handed certificate by Judge John Kraehenbuehl. Other Sectional winners are Albert Kurtson and J. Stewart Stein.

PRESENTATION of framed certificate is made to R. E. Bevan, right, by C. O. Martin, Vice-President, South Pacific Coast Region after placing first in the contest in that Region.

Church Lighting—On a Budget

By EARL A. DOMONEY

RELIGHTING the First Methodist Church of Saginaw, Michigan, stands out in my experience for five reasons:

First: The lighting installation was achieved on a limited budget.

Second: With the exception of one application, the entire job used incandescent lamps.

Third: The cooperation between architect, lighting engineer and electrical contractor was 100 per cent.

Fourth: This installation demonstrates how modern light sources can be fitted to a structure that was built in the gas light and oil lamp era.

Fifth: The congregation likes the job.

My story starts 100 years ago — in 1851 to be exact. At that time a small group of people in the Village of Saginaw started the First Methodist Church there. In 1886 they completed the present structure, which makes it 66 years old. As part of the Centennial celebration held in October, 1951, relighting the old building was considered.

In looking over the extent of the job, as lighting consultant, and viewing the pitiable condition of the old church, I recommended in effect: "Why not get an architect as well into the picture, and do a real renovating job?" This sounded reasonable to the church's Building Committee, with the usual reservations as to budget, and Mr. Glenn Beach, a Saginaw architect, was engaged — both architect and lighting consultant to work as a team.

The church was typical of its period; tall spire, rose window in front, arched side windows. Our first view of the interior, as we sat in the back pew discussing the job, is shown in the "before" picture on the next page. High choir loft, dark woodwork, elevated pulpit and gilded organ pipes were no

This installation won first prize in the contest for "My Most Interesting Lighting Job" conducted by the Michigan Section, the Great Lakes Regional Conference, and the Lighting Service Forum at the Chicago National Technical Conference, I.E.S. Mr. Domoney is lighting engineer at Consumers Power Co., Jackson, Michigan.

Before renovation.

doubt the pride of the village parishioners 100 years ago. The pendant fixtures shown in the "before" picture came from a local department store ten years ago when the lighting was changed. The small cross hanging from the top of the arch is made up of bare lamps and provided a wonderful glare source to lull the congregation into slumber during the sermon.

As we discussed the problem, from the back seat of the church, the lighting design seemed to fall into four sections.

First: The architect thought he might be able to pull out the organ, lower the choir seats and possibly install a large cross with a dossal behind it. Special lighting for the cross, dossal and choir would be needed.

Second: The pulpit, which the architect thought he could lower, would need some special lighting, possibly spotlights located somewhere on the ceiling.

Close-up of our indirect fixture design.

Third: We both agreed to eliminate pendant fixtures. Lighting the main body of the church would be a combination of recessed downlights installed in the flat part of the ceiling, plus some indirect lighting from the sides of the church. As we looked for a location for the side indirect lighting, we decided that some kind of unit might be installed at the base of the side arches, removing the plaster knobs. As the walls were solid masonry, this was also the only location where wiring could be provided without too much cost.

Fourth: Control resolved itself into dimmers, one for the choir area, one on the downlights, and one on the indirect lighting.

About six months later, we sat once more in the back pew. The picture on the opening page of this article shows, as best one can in black and white, how the church looks now. Let us take a look at the four lighting problems and see how they were solved. We discovered very quickly that there was no place in the choir area where we could put overhead lighting, so we had to *make* a place for the lights. This was done by moving the wood paneling out from the back wall about 12 inches. In the recess that resulted, ten 150-watt reflector lamps were installed. This accomplishes two things; it lights the dossal behind the cross and at the same time light reflects from the top of the arch providing lighting for the choir. We are not getting a very high level of illumination here, the value being between 5 and 6 footcandles. However, we had to choose between increasing the lighting level with more lamps and thus increasing the brightness of the arch, or using the lower illumination value, and keep the brightness at a comfortable level. However, it is a highly diffused light and as the choir faces the congregation, it comes from behind to light their hymn books. Further, this solution didn't cost much money.

Lighting the cross was a different problem. The cross members are channels open in the back. Inside the channels are installed 200 ma slimline lamps, which cross at the intersection. Remote ballasts are mounted in the trough below. We feel this provides one of the most attractive effects of the entire job and is the only spot where fluorescent lamps are used. Again, it didn't cost much.

The pulpit was replaced and located at a lower level. Illumination here is 30 footcandles on the Bible. The lighting is achieved with two 400-watt spots directed through 6-inch holes in the sloping part of the ceiling. Locating spotlights perfectly is easy if you happen to know an old sea captain with a sextant. After you decide on the angles at which you wish the spots to shine, you merely set the angle on the sextant, stand in the pulpit, look

through the eye piece, and where it points is where the light should be located. Fortunately the architect was a Navy man, and he has a sextant.

In the main auditorium it was not too difficult to locate the downlights. The job would be improved if the units were farther apart crosswise, but that would have meant mounting them in the sloping ceiling and angle units cost more money. We planned on using ten 500-watt downlights but money dictated what we could do, so we used eight and the last two, in the back of the church where they are not objectionable, are "hihat" units using reflector lamps. So we saved $200.00.

Finding a fixture for the indirect lighting consisted of our supplying dimensions necessary to install four reflector lamps and the architect supplying the know-how to make the outside shell architecturally correct. We tried square designs, octagon ones, round ones, long ones, and short ones, but none seemed to be right. Finally one day we adjourned to the corner drug store for a coke. The waitress served it in one of those paper cone containers in which the holder is a large cone above to hold the cup, and a smaller cone for the base. We both took one look — there was our design. Cut it in half lengthwise, and we have our fixture.

In its manufacture, again money was the deciding factor. The budget would not stand the original quotation, so cooperation came to the rescue. The architect made detailed drawings. A heating contractor with a good tin shop made them up. The painter on the job put on the finish. The electrical contractor wired them.

The illumination level in the main church auditorium with downlights and indirect lights on full is a very even and comfortable 10 to 12 footcandles.

No matter how good a job may be, the real test is whether the owners are satisfied. So I started asking questions. First, the architect — "Why do you like the lighting?" His answer, "I like it because it shows how modern design can be incorporated in an old structure and produce a pleasing result." Dr. Morris, the Minister: "I like the lighting for a number of reasons. It provides variety during the church service. The congregation is more attentive and more plentiful, and it is wonderful for weddings." Art Sursaw, church member: "I have a much greater feeling of reverence when I go inside the church than I ever did before. I think Dr. Morris' sermons have improved, or perhaps they sound better because I stay awake more than I used to." So everyone is satisfied.

The Shriner's Syria Mosque

By HUGH S. JAMES

THE SYRIA MOSQUE in Pittsburgh is a very large building, having very large rooms. The local chapter of the fraternal organization which owns it has a membership of 25,000 people; the shows they present in their Mosque require four evenings and one matinee to accommodate just the membership alone. Relighting such an area was a most interesting job since it provided exceptional and engaging opportunities to apply modern illuminating engineering principles and ideas. Each of the several areas within the building, by nature of its construction or use, presented its own particular problems. The job was a real challenge to thought, practicability, economy and cooperative planning in providing an installation completely satisfactory to the many concerned in the final results.

In addition to the Mosque's large auditorium, seating about 3000 people, there is a large banquet hall on the lower ground level used for dinners, exhibits, meetings, expositions and dances. Because of its vast size, it is not uncommon to serve as many as 1500 dinners in one evening, or have 1000 couples dancing. The board of directors realized that this building could provide a wider service to the community, and justify to a greater extent the investment already made in the building if its facilities were improved, expanded and offered to a greater number of users. Relighting played a large role in this plan.

The installation was made after several different sets of plans were prepared, revised, discarded and redrawn. To complicate matters further, an addi-

This installation was first place winner in the contest for "My Most Interesting Lighting Job" conducted by the Pittsburgh Section, taking first place also at the East Central Regional Conference, and second place at the Chicago National Technical Conference finals. Mr. James is a lighting engineer with the Duquesne Light Co., Pittsburgh, Pa.

The flexibility of the lighting system in the banquet hall in the two views, shown above and below, extends from 5 ft-c for dances to 75 ft-c for banquets and expositions.

tion by new construction was added to the relighting study of the existing building. The job then became an interesting plan to blend the lighting so that the "old" joined the "new" without distinctions. The additions proposed added pedestrian and vehicle ramps to a new ground floor entrance lobby to the banquet hall, a new first floor theater lounge with remodeling and redecorating of first floor corridor, check rooms, entrance lobbies, stairways, rest rooms and a balcony lounge with rest room facilities. Relighting of the existing areas was to be planned along with the lighting of the new addition so that they would blend together.

Probably the most challenging problems were presented by the banquet hall with its many diversified uses. Its solution combines fluorescent and incandescent systems. The fluorescent lighting is in rectangular patterns of two-lamp recessed troffers equipped with egg-crate louvers. These might be called "stacked patterns" with a smaller rectangle surrounded by a larger rectangle. The incandescent lighting is provided with recessed distributing (wide spread) type silver mirrored glass reflectors with 100- or 150-watt incandescent lamps, and equipped with concentric louvers. This design provides a wide variety of illumination levels for the varied uses of the room. Illumination can be adjusted from 5 footcandles for dancing, and less if color filters are used, to a maximum of 75 footcandles for exposition purposes. Any number of intermediate levels may be obtained with the flexibility which was provided in the wiring, and by the lighting design. Each pattern is controlled so that full or partial patterns can be used and in almost any combination since nearly all of the 104 circuits on the four panels in this room serve lighting and outlets in the room. Brightnesses are carefully balanced, with white acoustical ceiling, light green walls, and maple floor. Most notable during installation was the fact that although considerable space existed above the present ceiling in the banquet hall, and this was known when earlier plans were made, the cost of the job could be minimized on the ceiling part if as little as possible of the ceiling was disturbed. By working closely with the air conditioning contractor, this was accomplished so that for such a large room little plastering was done before acoustical tile was installed.

The lighting system for the first floor corridor and lounge employs recessed fluorescent coffers having eight 48-inch 40-watt white lamps in each unit. These units are equipped with louvered panels having 4-foot by 4-foot by 4-foot cells. The illumination is 40 to 50 footcandles in service with fourteen 4-foot coffers in the corridor and twenty 4-foot coffers in the lounge.

The balcony lounge is lighted with six rows of recessed two-lamp troffers equipped with egg-crate louvers, to an illumination level of approximately 40 footcandles in service. Other areas relighted, but which are not shown in the pictures, included two entrance lobbies, four check rooms, two stairways from corridor to banquet room, entry corridors and rest rooms.

Aside from the lighting, this installation ultimately required the installation of an entire new service, which saw this customer being no longer served from a 100-kva single-phase transformer on 115/230-volt service for his lighting and a small power bank for three-phase power. A double vault was constructed with two separate four-wire, three-phase banks of transformers served from separate circuits with automatic throw-over switch. With banks designed to carry combined power and light load, a failure in either circuit will not interrupt service.

Airport Apron Lighting

By H. N. McINTYRE

MANY ATTEMPTS have been made to improve the lighting system of the apron at the General Lawrence Logan Airport, Boston, Mass. And in March 1952 a trial installation of fluorescent floodlighting was completed. This trial installation has received the full approval of the American Airlines operations personnel. The result is that they simply don't want to be without it.

The words "apron lighting" have a multitude of meanings to the people who run the business end of an airport terminal — especially if their apron lighting is poor. To the night operations manager, poor lighting on the loading apron means slow turn-arounds, lost time, fouled schedules. To the night maintenance chief, it means inefficient, slow, expensive servicing and costly mistakes. To the pilot it means confusion.

Poor apron lighting means something also to the passengers these people serve: it means danger!

Visualize the predicament of a pilot approaching the apron. At night this man is carefully darkadapted. After landing he cautiously guides his unwieldy craft toward the apron. His airplane is built for flight, not for easy maneuvering on the ground. One misstep off the taxiway may ruin expensive landing gear; may mire the plane for hours before it can be pulled out. A pilot may frequently be hindered by glare from the apron floodlights. He may safely reach the ramp, only to roll into even higher brightness zones of high-powered ramp floodlights, perhaps unshielded. He actually may be prevented from seeing the correct path through a maze of dim blue taxiway light.

For many reasons conventional floodlighting methods cannot practically and economically prevent these potential hazards. At most commercial airports large apron areas must be lighted, resulting in impractically heavy electrical loads, since for acceptable uniformity, high levels of illumination must be used. Discomfort to the pilot and reduced safety are invariably obtained with the standard attempt to spread a few lumens over a wide area. The contrast of a few high-brightness sources against low level illumination produces more glare than useful light.

At the Logan Airport a portion of the incandescent floodlighting was replaced with fluorescent

This installation was first place winner in the contest for "My Most Interesting Lighting Job" conducted by the New England Section, taking first place also at the Northeastern Regional Conference, and third place at the Chicago National Technical Conference finals. Mr. McIntyre is with the General Electric Co., Illuminating Laboratory, in West Lynn, Mass.

luminaires, in a trial to provide good uniformity of illumination and to reduce glare. Compared with the amount of light which can be seen on horizontal and vertical surfaces in front of the installation, the luminaire reflecting surfaces proved relatively dim. This feature is one great advantage of fluorescent floodlighting: it makes possible high light output with low source brightness.

Eight giant fluorescent floodlights are used in this installation. Each of these units contains two 8-foot slimline lamps operated at 600 ma. Total available light at each luminaire is over 10,000 lumens. The eight floodlights are bracketed to the hand rail which borders the observation deck looking toward the runways. This places them two feet above the roof edge, for a total mounting height of 17 feet. Positioned co-linearly the floodlights are spaced about 25 feet from center to center.

This installation illuminates an area approximately 150 feet wide by 200 feet long to an average initial level of 1.0 footcandle. Moving away from the lights toward the runways, the illumination level falls off uniformly from about 4.88 ft-c at twelve feet from the lights to .03-.04 ft-c at 175 feet. Lateral uniformity, that is uniformity along lines parallel to the installation, simply does not vary at all until the end floodlights are reached.

This low mounting height, made possible by high lumen output and low surface brightness, increases direct illumination of objects seen from the ramp side; in addition, it has little effect on the degree of uniformity of illumination. The flat angles of projection improve silhouette effect as observed from the runway side of the apron.

In addition to increased safety and comfort, due to quality lighting, advantages claimed by the airport personnel for the fluorescent system are:

Servicing is speeded, turn-about time decreased.

Maintenance is more efficient and less expensive to the airline company.

Power consumption is less than that of the two incandescent floodlights previously employed.

Jack Woods, Operations Manager of American Airlines, says "the new fluorescents provide uniformly distributed, practicallly glare-free light. Pilots, loading crews and passengers say the fluorescents are far more comfortable on the eyes than conventional incandescent floodlights. In view of the heavy night traffic, our loading ramp requires high vertical light levels. The fluorescent floodlights facilitate and speed maintenance and loading between flights."

Eight-Point Program in Bank Lighting

By C. H. JOHNSON

IN PLANNING the banking floor of Bell Savings & Loan Association, Chicago, Ill., it was decided to emphasize informality, warmth, and, in general create a friendly atmosphere, in contrast with the cold monumental air of many banks. This requirement, coupled with the fact that it was a remodeling job into which a bulky air-conditioning system had to be incorporated, set up a difficult problem. Lighting played an important role in the solution of this problem by

(1) Furnishing varying degrees of illumination required in various areas.
(2) Serving to give illusion of height where ceiling height was deficient.
(3) Creating an inviting view from the street.
(4) Setting off various departments.
(5) Bringing out color of room finishes and appointments.
(6) Tying together areas with different ceiling heights.
(7) Contributing to solution of a smudge problem around air conditioning outlets.
(8) Making it possible to camouflage telephone operator's room with a mirrored window.

The banking floor consists of four distinct areas. Because of the effort to create an informal friendly atmosphere, barriers and private offices were almost entirely eliminated. The use of a different pattern of lighting in each area served to distinguish each department satisfactorily.

The work space behind the tellers' counter, where much detailed work has to be handled rapidly, is illuminated by long, continuous runs of three-lamp fluorescent units, about six feet on centers, parallel to the tellers' counter, and recessed in the metal-pan acoustical ceiling. This has produced maintained intensity of 55 ft-c. De luxe cool white lamps were used in this area.

The clerical desk area is lighted with these lamps also, except that the units are arranged in a series of rectangles surrounding the air-conditioning out-

This installation won first prize in the contest for "My Most Interesting Lighting Job" conducted by the Chicago Section and the Midwestern Region. It was a runner-up at the National Technical Conference. Mr. Johnson is with Johnson & Johnson, Engineers and Architects, in Chicago.

lets. This serves to vary the pattern of lighting and also ties in the air outlets to give a pleasing rosette effect. From the street, a pleasing repeat pattern is achieved. Illumination level is 50 ft-c.

In the ceiling over the clerical desk area, it was decided to use rough gypsum acoustical tile, a material not easily cleaned. With the rectangular pattern of luminaires, the enclosed area — most likely to become smudged, can be cleaned or replaced without leaving a tell-tale line of demarcation.

The executive area is lighted by chandeliers adapted to modern lines, one over each executive, producing about 30 ft-c. Three chandeliers in the Monroe Street front are framed, as seen from outside, by large rectangular windows, creating an attractive dignified effect.

The public banking lobby is lighted by a combination of indirect incandescent, recessed fluorescent, and recessed incandescent luminaires and by a cove surrounding the entire area, giving an average of 30 ft-c.

Ceiling height in the rather large public area is 12 feet. Over the tellers' area and the desk area, ceilings had to be dropped to 9 feet 8 inches, to accommodate air-conditioning ducts. A natural tie between these two heights was created by the cove lighting over the public area. This also reduced brightness contrast in the ceiling, as does reflection from the comparatively light floor. The cove was designed according to data published in 1949.*

Two rows of slimline lamps, one above the other, with staggered sockets, produced a uniform effect. De luxe warm white fluorescent lamps were used blending well with the incandescent.

The main indirect luminaires in the center of this area reflect light from domes inserted above the ceiling levels in space between concealed girders. These bronze luminaires each contain a 500-watt lamp. These domes, in addition to the cove, help raise apparent ceiling height. Wall finishes and other interior decorating were designed to emphasize the informal atmosphere.

A mirror lighting problem arose in connection with furnishing a one-way mirrored window for the telephone operator's room, which overlooks the general area. By using one fluorescent luminaire with one lamp only, sufficient difference in intensity between inside and outside light was achieved for proper one-way visibility, giving at the same time sufficient work light to the telephone operator.

All in all, 188 three-lamp units, wired for 40-watt T-12 lamps; and 96 two-lamp luminaires, also wired for 40-watt T-12 lamps, are used, all equipped with glass lenses. The cove contains a total of 80 64-inch T-6 and 35 42-inch T-6 lamps.

The results are illustrated in the photograph. The manager avers that he has received numerous compliments on the appearance of the premises as enhanced by the illumination. He asserts that the lighting is very satisfactory from the viewpoint of utility, and that its efficiency has permitted air-conditioning equipment sized within economic limits.

*Brown, L. C., and Jones, J. R.: "Engineering Aspects of Cove Lighting Design," ILLUMINATING ENGINEERING, Vol. XLIV, No. 4 (April 1949).

"Daylight" on a Stained Glass Window

By ROY E. BEVAN

"LET THERE BE LIGHT and there was light"—this passage, appearing in the first chapter, third verse of Genesis, is appropriate for my own most interesting lighting job. The problem was to illuminate the stained lead-glass window behind the altar of the Beverly Vista Community Church in Beverly Hills.

Without exterior lighting, the interior view of the stained glass window appeared dull at night. To determine the illumination necessary for the window to approach its daytime beauty, we proceeded on the assumption that stained glass windows are designed for the high levels of illumination found in natural daylight. After taking a series of daylight footcandle readings, the window was found to be most attractive on an overcast day with an average illumination of around 500 ft-c. To simulate these conditions, we had to design an installation which would have the same effect as a large area source and which would also illuminate the window to 500 ft-c. Another condition imposed was space limitation; the floodlighting equipment had to be placed within 13 feet of the window. It was also to be inconspicuous in order not to mar the beauty of the church facade.

To meet these requirements, we designed an installation which can easily be dismantled and stored when not in use, but which can be set up, when needed, at a distance of eight feet from the window. Three five-lamp clusters of PAR-38 150-watt spots were mounted on a steel pole, which is erected by being inserted into a sleeve submerged in the ground. In order to maintain the proper lamp aiming angles each time the pole is set up, the pole is locked in a predetermined position. This was accomplished by welding onto the pole a guide which fits into a slot in the sleeve.

The PAR-38 was chosen as the light source because of the low initial installation and maintenance costs. The installation will operate approximately 500 hours a year. With the 2000-hour life rating of PAR-38 lamps, relamping would be on the average of once every four years.

The artificial illumination on the window varies from 600 ft-c at the center to 350 ft-c at the edges. The average intensity is approximately 500 ft-c. Due to the comparative high transmission factor of several of the 100-odd pieces of glass, and the maximum beam candlepower of the PAR-38, the center of the beam was pulled 15 degrees away from the average line of sight of the seated congregation. This was done so that the average line of sight would never strike the candlepower curve of any lamp at a point greater than 1200 candlepower. All the panes of leaded glass have sufficient brightness and adequate diffusing properties which make it impossible to detect the 1200 or less candlepower of the light source behind the window. Thus, the window appears to be lighted with a large area source. The brightness of the window highlights from inside the church averages 35 footlamberts, while the background brightness varies from one to five footlamberts.

In physical stature this is a small installation, but if its size is measured by the appreciation of the minister and the congregation of the church, its stature is large indeed. They now have their beautiful window in the evening as well as during the day.

This installation won first prize in the contest for "My Most Interesting Lighting Job" conducted by the Southern California Section at the South Pacific Coast Regional Conference and was a runner-up at the National Technical Conference in Chicago, where it was presented for Mr. Bevan by Lt.-Colonel Walter Howard, U.S.A.F. Mr. Bevan is Lighting Consultant with Southern California Edison Co., Beverly Hills, Calif.

New Fluorescent Lamp and Ballast Design For Rapid Starting

By A. E. LEMMERS
W. W. BROOKS

This paper presents technical material which led to the rapid-start lamp and ballast. Lamp and ballast characteristics have been integrated in a manner to produce a fluorescent lighting system with unusual characteristics. It combines the desirable features of both of the two older systems, switch start and instant start. It eliminates the less desirable features of both.

THE NEW rapid-starting fluorescent lamp and ballast system described in this paper offers the lighting industry new concepts in high quality, rapid-starting, fluorescent lighting with considerable reduction in materials used in the ballast. This has been brought about by taking advantage of certain lamp characteristics and making a new lamp and a ballast which were integrated.

The idea back of this development was to make use of everything possible in both lamp and ballast characteristics to the end that a fast starting system might be made which would have the smallest, most efficient ballast consistent with high quality lighting using mass produced fluorescent lamps.

The present instant start systems suffer mainly in weight and overall efficiency. Even with this against them the advantages of starter elimination and fast starting have caused a growing acceptance. Lesser disadvantages are shorter life, higher loss, and a condition at the end of life which can cause ballast failure in some cases. All the ballast disadvantages of the instant start systems stem from the high voltages and volt-amperes needed for satisfactory starting.[1] Any reduction in volts and volt-amperes needed to start lamps improves the economics of fluorescent lighting. The new system is much closer to the theoretical minimum volt-amperes for starting than any of the older instant-starting systems.

The complex inter-relations between lamps and ballasts have been explored in relation to a reduction in starting volt-amperes for many lamp sizes. They can roughly be broken down to the following: 1. What happens to the starting voltage of ordinary lamps when cathode heat is supplied simultaneously with the voltage. 2. What happens to the starting voltage when starting aids are built into the lamps. 3. How the cost of supplying the cathode heat is made practically negligible.

Starting Volts — Cathode Heat Relation

In Fig. 1 the starting volts for 40-watt T12 fluorescent lamps have been plotted against cathode heating current under several lamp conditions. The same lamps were used in curves A, B and C. Ionization of the lamp atmosphere as well as cathode fall changes appear to be the cause of the abrupt drop. At the lower voltage end of the curves, glow has set in. Curve A is for lamps several feet removed from adjacent conductors. It seems evident that under these conditions cathode heat at 0.6 amperes has reduced starting volts by about 150 volts.

In curve B a starting aid in the form of a conductive stripe 2 to 3 mm wide was painted on the lamps lengthwise. In curve C the stripe was connected to one end of the lamp. Note how the effect of the starting aid, when connected, has added greatly to the effect of cathode heat. In curves B and C, as indicated by tests, the starting without cathode heat is damaging while the starting with heat is not.

This lowering of starting volts, however, has cost about 6 watts per cathode. To take advantage of the reduction in starting volts some means of reducing the cathode heat after the lamps start must be found. Such a preheat current, if left on, is both wasteful and destructive during operation. Our work proceeded in two directions: doing what was possible with ordinary lamps and changing lamps so that full advantage of starting aids and cathode heat could be taken.

Present Lamps and Their Limitations

Examine the voltages needed to start ordinary lamps. Under many circumstances starting volts would be approximately as shown in curve C, Fig. 1. This would be for lamps in grounded metal fixtures

A paper presented at the National Technical Conference of the Illuminating Engineering Society, Sept. 8-12, 1952, Chicago, Ill.
AUTHORS: General Electric Co., Lamp Development Laboratory, Cleveland, Ohio, and General Electric Co., Ballast Engineering Div., Fort Wayne, Indiana, respectively.

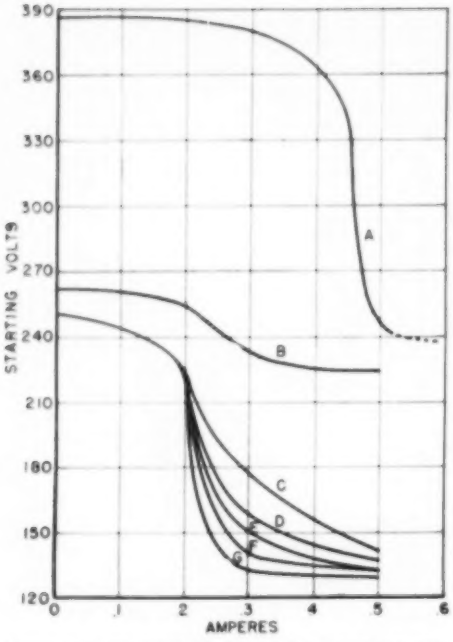

Figure 1. These curves show how cathode heat and starting aids are related and how they lower starting volts in 40WT12 lamps. Text explains conditions.

at relative humidities less than 80 per cent. However, under high humidity or in the absence of a metal fixture, the starting volts would be as shown in curve A, Fig. 1. At 90 per cent or higher relative humidity, the starting volts on new lamps could be much higher. Such a condition is shown in Fig. 2. Here the humidity effect and the effect of residual gases present in lamps which have been burned but a few minutes are shown to be additive.[2] Residual gases do not permanently clean up until several hours of burning. These gases are mainly nitrogen from nitrogen-mercury compounds.

Considering these factors, one would set the nominal starting volts with cathode heat at about 330 volts for 40WT12 lamps. When open-circuit volts are raised this high to overcome such adverse conditions we find that under favorable conditions this high voltage starts the lamps before the cathodes are sufficiently heated. This shortens life and produces early end darkening. Not only can we lose the benefits of a "fixture-type" starting aid under high humidity but damage results under good starting conditions if the ballast open-circuit volts are high enough to obtain starting under adverse conditions. For good results we either have to make sure the starting aid is not nullified or is never present.

The first condition cannot be met without redesigning the lamp. The second, however, can to some extent be had by making the mid-connection in the auto-transformer ballast the same potential as the fixture or starting aid. This reduces the effect of the starting aid and makes the starting more dependent upon cathode heat and end glow. Such an arrangement permits at least a 25 per cent reduction in starting volts under most humidity conditions (80 per cent or less). If non-starting at lower humidity (60 per cent) were permitted, a 40 per cent reduction is possible. With the first arrangement giving reasonable starting, a reduction of 25 per cent to 30 per cent in life may be experienced. In the second set of conditions normal life may be experienced but non-starting will frequently occur.

To get this type of starting (that is, without starting aid) an end glow at the cathodes is needed. Regular 40-watt lamps will have an end glow if heated with approximately 0.6 amperes through the cathode. A current of such magnitude if left on during lamp operation, causes the cathode spot

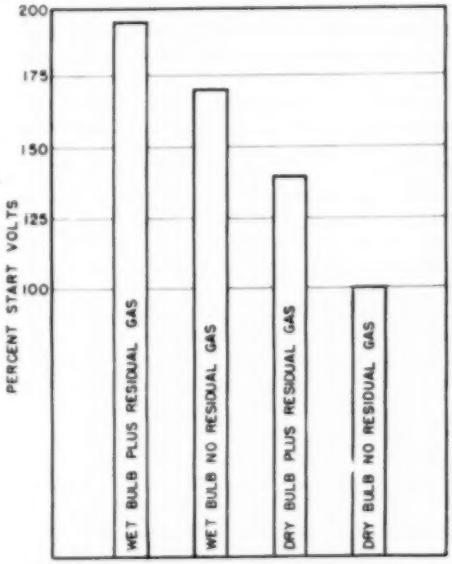
PERCENT START VOLTS
WET BULB PLUS RESIDUAL GAS
WET BULB NO RESIDUAL GAS
DRY BULB PLUS RESIDUAL GAS
DRY BULB NO RESIDUAL GAS

Figure 2. An example of how lowered bulb resistance, due to humidity, and the residual gases, which return in lamps during storage, act together to raise lamp starting volts when used with a grounded fixture and with cathode heat. Comparing this diagram with the curve in Fig. 4 will show that the humidity causes an effect greater than that due to removal of starting aid.

to overheat, resulting in early end darkening, shorter life, and increased wattage loss. This cathode current is, however, easily reduced by several methods as shown in ballast circuits in Fig. 3. Circuit A uses a filament supply transformer with its primary across the lamp. Here the cathode heat is reduced by the change of open-circuit volts to lamp volts.

With circuits B, C, and D there is a reduction in cathode heat by neutralization, caused by an opposing voltage after the lamps start. Perfect neutralization is difficult to obtain. The vector relations of the various circuit elements of a practical ballast do not yield any two elements 180° out of phase. Thus, only partial neutralization is possible unless the lead-lag type as in D is used. Ballasts incorporating all these various neutralizing schemes have been made and tested. None is impractical of manufacture. The particular one used would depend on the lamp size, type of service, and economics of both manufacture and use. There are only two reasons for neutralizing the preheat current. These are to prevent cathode overheating and to conserve watts.

In trying to apply these starting techniques to the regular lamps two factors prevent the full benefits of reduced ballast size and cost. One is the absence of a lamp starting aid needed under humid conditions. The other is the increased size and cost of a ballast employing the cathode heating and neutralizing elements. The best compromise also gives some reduction in lamp life. The new lamp has been designed to overcome these disadvantages.

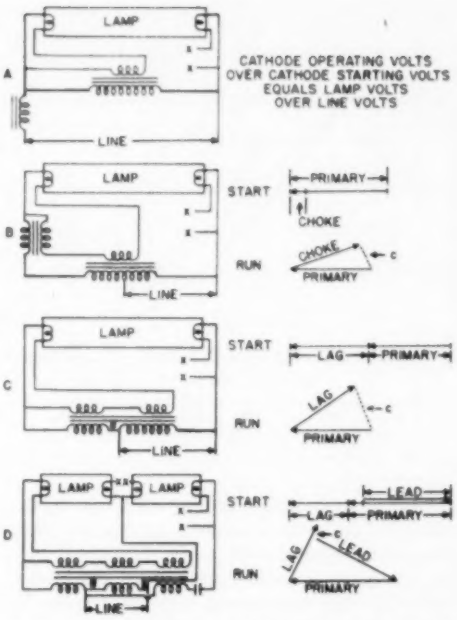

Figure 3. These circuits show the various ways in which cathode preheat may be reduced. The xx points indicate a connection is to be made to a cathode heater circuit which was omitted for clarity. The vector diagrams indicate in a general way how the voltages in the cathode heater circuits swing about at run to cause neutralization. The C indicates the magnitude of the cathode load.

Design Features of New Lamps — Aids

Let us examine the results of the new lamps which employ starting aids. Curves C, D, E, F, and G, Fig. 1 show how five different starting aids lower starting volts when used in conjunction with cathode heat. Curve C shows the effect of the grounded stripe. Curve D shows the effect of a grounded fixture. Curve E is for an outside grounded transparent conductive coating, as compared with an inside conductive coating in Curve F. Last and most effective, Curve G, a transparent conductive coating with a potential difference of at least 150 volts to either cathode.

The action of all of these starting aids is similar. All have the effect of reducing the cathode heat needed to obtain the greatest reduction in starting volts. The choice of any of these starting aids is, of course, determined first by whether they reduce the starting voltage sufficiently for the application in mind, and second, by economic and manufacturing considerations. For 40-watt T12 48-inch lamps, all of them reduce the starting volts enough to make use of the most economical and efficiently designed ballast. Economically, the use of the grounded fixture is a good choice. This requires the lamps to be coated with a water repellent material such as Dri-Film.* Instant-start lamps are presently so coated. The effect of these starting aids in conjunction with cathode heat has been investigated in lamps of all the sizes commonly available. Fig. 4 shows the increase in starting voltage when starting aids are not employed for various lengths of T12 lamps.

Cathode Heat — Demand and Effect on Ballast

The cathode heat alone in all sizes has given a reduction in starting voltage of 80 to 125 volts without end glow. The variation is believed to be due to differences in work function at different temperatures between different cathodes. A cathode abused by a few hundred cold starts will give less reduction of starting volts upon being heated. Burning for some hours will frequently return it

*Reg. General Electric Co. Trade Mark.

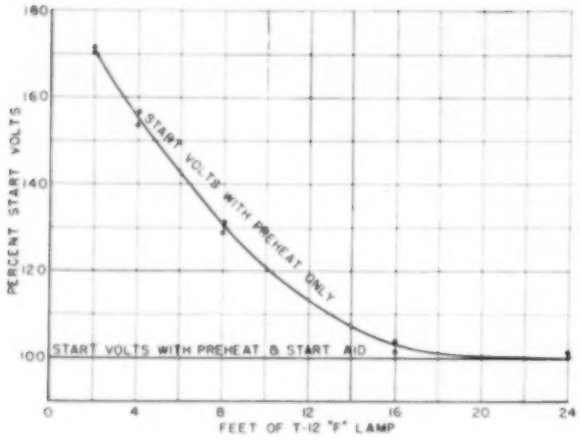

Figure 4. Here the effect of removing a starting aid in raising starting volts on lamps with heated cathodes is shown in relation to length of lamps in 1½-inch diameter. The well seasoned lamps were suspended by strings in the center of a room and the starting aids were applied and removed. The 16- and 24-foot points are made up of lamps in series.

to its original condition. The cathode temperatures corresponding to the 0.3-ampere point in Fig. 1 is an incipient red heat (500 to 550°C). It is in this temperature range, with a starting aid, that under limited current conditions a faint glow suddenly appears as a streamer from a cathode.

If the cathode heat supply is designed to stabilize the cathodes at this temperature very slow starting results. If, however, the cathode heater supplies additional current, starting will begin as the cathode passes through this minimum temperature. On the 40-watt cathodes about 0.380 amperes will cause starting in less than one-half second. At 80 per cent of nominal line volts it will still heat the cathode to the minimum starting temperature, but starting will be slower. At rated line volts the preheat wattage per cathode will be approximately 2.6 watts. In a 40-watt lamp the two cathodes would consume about 13 per cent of lamp watts. After starting, simple bucking current would take this down to about half of this value. In two-lamp ballasts lead-lag neutralizing reduces this to a very few per cent. The 0.380 amperes do not overheat these cathodes during operation, but neutralization is employed only for reduction of watts loss.

A very interesting phenomenon occurs as one applies heat to the cathode while it is operating at rated current. The temperature of the cathode spot actually decreases as one increases the average cathode temperature. The cathode spot becomes more diffuse and spread out. With excessive cathode heating, however, the cathode spot again increases in temperature. If lamps are operated above the normal hot-spot temperature earlier end darkening and shorter life occur. Below this point long life and a reduction of radio noise are experienced.[3] Radio noise may be reduced to as little as 1/200 of that normally experienced.

New Cathode To Simplify Ballast

Wattage loss from leaving cathode heat on without neutralization is high primarily because of cathode resistance (wire size and length). Cathode wire size is mainly determined by the arc current, while the length or total cathode resistance has mainly been determined by the older requirements of establishing end glow with switch-type ballasts. This has resulted in cathodes which, if heated with the currents indicated for this new type of starting, have a voltage between 7 and 8 volts. We have used shorter cathodes having from 2 to 4 volts at the desired preheat current. Results as shown in Fig. 5, Curve A, indicate the 3.5-volt cathodes of an instant-start type,[4] carrying an emission material quantity approximately the same as the longer cathodes, yield perfectly normal life (7500+ hours). There is also evidence that such lamps may also give normal life on regular switch-start ballasts (Curve B).

With these shorter cathodes the loss due to preheat, fast-starting circuits, is low enough to ignore, even when no neutralizing is used. This effects an appreciable reduction in ballast complexity and cost. Theoretically the loss in the 40-watt size is about 1.2 watts per cathode. This does not, however, appear in the final result. The watts expended in the cathodes lower the lamp volts by reducing cathode fall. If lamp current is the same for cathodes with heat on as with heat off the lumens are the same even though the lamp voltage is lower.

It is extremely difficult to measure lamp watts with any certainty in such a circuit. Because of

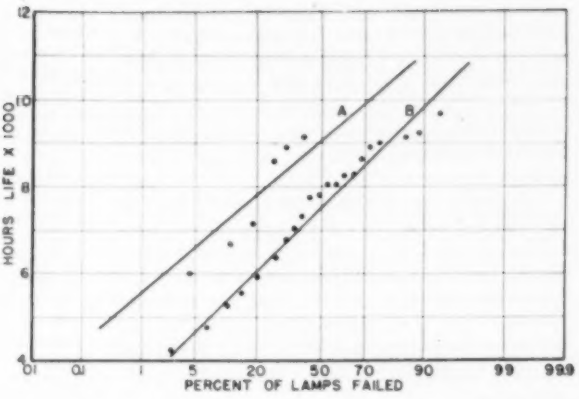

Figure 5. Curve A is the result of a 14-lamp test of mixed lots of lamps with a small 3.5-volt cathode and Dri-Filmed bulbs burned in overhead factory fixtures with 3 hrs. per start. The ballasts were a preheat, rapid-start type. Curve B is the result of 25 lamps made the same as for Curve A but burned in fixtures equipped with switch-start type ballasts and No Blink starters.

this we prefer to measure input watts and lumen output. With such measurements we find that in the 40-watt two-lamp ballast the cathode heat for two lamps can cause less than 3 watts increase in watts input for the same lumen output. Twenty-watt lamps in these circuits have shown on occasion no change in input watts for equal light output when cathode heat is left on during operation.

These starting principles can be applied with advantage by modifying any ballast circuit now used, such as low reactance, high-reactance, lead-lag, or the series type. In industrial lighting where sometimes three-phase ungrounded supply systems are used, the 40- and 100-watt lamps in single or lead-lag form of ballasts might not start if a ground exists on the phase connected to the black lead. Special longer lamps or series operation of lamps circumvent this condition. In the series type additional benefits are obtained because the cathode heat permits very low starting current without lamp damage. In a series circuit each lamp has its starting volts reduced by approximately 100 volts due to cathode heat. Thus even in long lengths of lamps where the starting-aid effect is less, considerable reduction in starting volts, without lamp damage, is possible using these preheat, fast-starting principles. In single lamps or lamp combinations up to 8 or 10 feet a starting aid is quite essential.

In the interest of ballast simplicity, low cost, and in lower wattage loss, a low voltage type of cathode is needed.

Summary

Lamps made as outlined and operated in the preferred systems discussed yield rated lumen output with fast starting, at an increase in total watts over preheat switch starting of from zero to 5 per cent. In present instant-start systems this loss is approximately 10 to 15 per cent.

Major savings, however, show up in ballast cost,

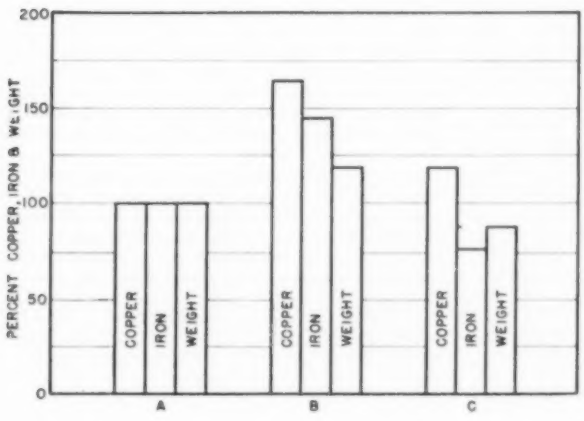

Figure 6. Bar graph of relative copper, iron, and total weights for three 40-watt, two-lamp commercial ballasts. A is a standard switch-start type ballast, B is a series instant-start and C the new rapid-start ballast.

material and weight. As a general rule the preheat fast-starting ballasts cost approximately the same as equivalent preheat ballasts plus starters and starter sockets, except in sizes where no ballast transformer is needed. Ballasts for operation of certain lamps and combinations in series can be lower in cost per lamp than existing preheat switch-start models.

Specifically consider what this means in terms of material and weight for a two-lamp 40-watt ballast. When compared to a switch-start ballast the new rapid-start ballast uses 18 per cent more copper but 23 per cent less steel (Fig. 6). This weighs 12 per cent less. The series instant-start ballast uses 64 per cent more copper and 45 per cent more steel than the switch-start ballast. This weighs 18 per cent more.

There is still one more advantage apparent at this time. With this type of lamp and ballast combination, ballast life is not reduced by the abnormal currents and voltages which may occur in high-voltage, instant-start systems at the end of the life of a lamp.

This new system offers the lighting industry new values and concepts of low cost, high quality, and rapid starting fluorescent lighting.

The authors wish to express their appreciation for the help they have received from their respective groups and in particular A. Kovach and C. E. Strecker.

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DISCUSSION

DR. J. N. ALDINGTON*: I thought it might be of some interest to comment on the authors' paper by comparing the new fluorescent lamp and ballast design, described by the authors, with our practice in Great Britain.

The preferred circuit, if I have understood the authors aright, provides rapid starting by the provision of cathode preheat from secondary windings on the current limiting reactors. The lamps are coated with a water repellent material. In Great Britain the so-called instant start circuit which has been in use for a number of years, employs cathode preheat by secondary windings on the reactance but due to our 200-250-volt mains no voltage step-up is necessary except that provided by the summation of the secondary windings to the mains voltage. This results in a very simple item of control gear and the current through the electrode is kept to a minimum, as soon as the lamp strikes, by suitable design of leakage characteristics of the cathode heater windings.

The lamps used on the instant start circuits are standard in all respects except that after manufacture an electrically conducting stripe is provided running the whole length of the lamp and coated on the outside of the bulb; arrangements being provided for this stripe to be earthed.

In our experience we are able to confirm the various beneficial factors mentioned by the authors except in one instance, on page 591 the authors mention some reduction in lamp life if the circuit is designed for normal lamps. This result is contrary to our laboratory and field experience in Great Britain. We can, however, confirm the reduction in the average cathode temperature on this circuit, the reduction in radio noise, and the long life and good starting under adverse temperature conditions. As a matter of fact, it is the practice of at least one manufacturer in Great Britain to use only instant-start lamps and ballasts in fluorescent street lighting fittings. Good performance has been reported over many thousands of lamps in such fittings during several winters.

G. K. HARBACKE*: It is very refreshing to see new developments constantly coming along that improve lighting, and, hence, advance the application of new lighting principles and improve the lighting market. This paper describes one such outstanding development which seems to offer opportunities for high quality, rapid starting, fluorescent lighting with a considerable reduction of materials used in the ballast.

Ballast weight and ballast losses have always been handicaps in promoting fluorescent lighting. The fact that this new concept materially reduces these two factors is encouraging. As pointed out in the discussion of other papers, favorable economics always in the long run advances the interest of the profession and industry.

One disturbing factor in fluorescent lighting systems is the starter maintenance problem. The new concepts described in this paper tend to eliminate this handicap.

It is interesting to note in Fig. 5 of this paper that there is some possibility of using these new type lamps on conventional circuits. We need always to simplify our lighting equipment; and, while new lamps tend to do this, they also complicate the problem unless they replace old ones. I hope the time is not too far off when this new lamp will entirely replace standard preheat type fluorescent lamps.

This paper confines itself with the 40-watt lamp; however, indications are that this same principle might be applied to any fluorescent lamp, in which case it might well lead the way to higher wattage fluorescent lamps which cannot be economically justified in many cases under present designs. Higher wattage lamps have always been stimulants to the lighting business and particularly to the expansion into new fields of fluorescent lighting.

Regardless of the future developments along these lines, this particular development is indeed a shot in the arm, as it will very much help stimulate the fluorescent lighting market which has been sagging the past few months. Any new bona fide development tends to do this, and this particular lamp looks like "just what the doctor ordered."

H. E. BACHMAN**: The step-by-step development of a fast starting and economical fluorescent lamp and ballast combination, as presented by Mr. Lemmers and Mr. Brooks, was

*Siemens Electric Lamps & Supplies Ltd., Preston, Lancashire, England.

*Public Service of Northern Illinois, Chicago.
**Westinghouse Electric Corp., Lamp Division, Bloomfield, N. J.

extremely interesting. Undoubtedly this system, or some variation thereof, presents the fluorescent lighting industry with new values and concepts of improved lighting.

Unfortunately, as is usual with most new ideas and developments, there are some very distinct disadvantages and serious problems presented by this system. It is our firm conviction that the ultimate consumer must be adequately forewarned of these as possible pitfalls and, even more so, possible reasons for ultimate non-acceptance. Firstly, there is a very definite non-starting condition on a sizeable percentage of present lamps when utilizing 106 volts line. *It is possible* that the lamp starting voltage can be reduced by up to 15 volts by a slight reduction in lamp gas fill pressure. This design change would have a relatively insignificant effect on lamp life and lumen maintenance. I would, therefore, like to question the authors as to whether this possibility was considered in the design of the rapid start lamp.

A second drawback of this new system is the imminent danger of high resistance contacts, also causing non-starting of lamps. This resistance may arise from the filament connections inside the lamp, lead wire to base-pin contact, or in the lamp sockets, particularly after dust and corrosion set in. This one single item of resistance is a challenge to both lamp and socket designers.

Thirdly, because of the physical interchangeability of the 48-inch bipin instant start lamp with the present rapid start lamp, a very serious ballast overheating problem *may* exist when the 48-inch bipin instant start lamp is used erroneously in this type service. Theoretically, it appears that the ballast may burn out in a relatively short period of time after the preheating windings are short-circuited. Have the authors taken this into account and is the condition of any serious consequence?

Because of the numerous maintenance disadvantages of the series-sequence type of circuit, we question the advisability of using this type of circuit in conjunction with rapid start. Since the lead-lag circuit can be as easily and economically applied, we urge its use.

As a last question and comment I would like to ask what effect ambient temperature has on the starting voltage curves of Fig. 1, or more specifically what safety factors are needed for reliable starting at 40F and 50F?

Notwithstanding all the enumerated deficiencies of rapid starting as it now exists, we feel the information presented is a definite step in the right direction, especially if the indicated improvements are effected and a single lamp can be used for both preheat and rapid start service.

H. U. HJERMSTAD*: This paper represents an evolution of technical improvement in which it has become possible to design a lamp ballast system having several desirable features. I personally feel that the use of this system will be extended to several sizes and types of lamps in the next few years.

I wish to point out that the circuits shown in Fig. 3 are not actually employed with rapid start lamps. The circuits shown in Fig. 3 all are of a type in which the voltage of the cathodes reduce the moment that the lamp ignites. In the new design of the rapid start lamp, as I understand it, the cathodes have been designed so as to permit continuous application of the cathode voltage. Once the cathodes have reached emission temperatures, the voltage required to start the lamp is then lower and the arc then can be struck. Since the starting voltage of the rapid start lamp is much lower than that of an instant start lamp, care must be exercised in ballast design so that the peak voltage of the ballast will not cause the lamp to instant start rather than rapid-start. By the same token, close tolerances must be maintained on the striking voltage of the lamp or else the lamp will fail to start if the striking voltage becomes too high: *i.e.*, higher than the open circuit ballast voltage. Care in manufacture has to be exercised by both ballast and lamp manufacturers to make a compatible combination.

Most of the circuits actually employed are series sequence ballast designs similar to the early sequence-start ballasts for instant start lamps with the addition of cathode windings. With this type of circuit, ballasts will run at very low V.A. (hence very cool) under abnormal conditions (with either lamp out). Incidentally, they will run cool if either lamp should act as a half-wave rectifier. Several designs provide for excellent regulation maintaining lamp wattage and light output over a wide range of primary voltage.

The lower starting voltage makes it possible to design a ballast having a relatively low peak to rms value of operating current. This should be very helpful toward lamp life since it has been shown in preheat type lamps that ballasts having lower crest factor will provide a longer lamp life.

I believe a very desirable feature of the rapid start lamp is that the radio frequency noise generated at the cathode will be materially reduced. This should be extremely desirable as no doubt, this system will be used greatly in home lighting.

Since the cathodes of the rapid-start lamp will maintain the emission temperature without regard to the lamp current, it will become practical to design ballasts with a dimmer arrangement. This again, for home lighting might prove to be rather interesting.

The method of lamp wattage measurement that has been proposed on this system is rather involved. There is great need for a more accurate voltage wattage method of measurement. I sincerely hope that it will not be too long before there can be industry agreement on a more practical solution to this problem.

I have a question — When lamp #2 (the one shunted by a starting capacitor) in a series sequence circuit fails, the current through lamp #1 will drop to just a few milliamperes. Will continuous operation under this condition change the electrical characteristics or harm or shorten the life of the #1 lamp in any manner?

E. F. LOWRY*: After a careful study of this paper which is of considerable interest, particularly in view of recent commercial announcements, I find a number of statements which, to me at least, are very confusing.

(1) The authors refer to Curve C, Fig. 1, in one instance as applying to the case of a grounded metal stripe and again as referring to lamps in grounded metal fixtures. Which is correct?

(2) Quite a point is made of the deleterious effects of instant starting. Is instant starting with these new lamps and ballasts any more severe than with other well known instant start circuits now in common use? It is my understanding that instant start lamps today are lasting about 7500 hours which is in excess of their economically useful life.

(3) At the top of page 590, column 2, the authors state: "For good results we either have to make sure the starting aid is not nullified or is never present." This startling state-

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*Sylvania Electric Products, Inc., Salem, Mass.

ment is made even more confusing by the discussion which follows, wherein we are led to believe that we must expect either: (a) a reduction of 25 to 30 per cent in life, or (b) a situation where non starting will frequently occur.

(4) On page 589, we are led to believe that Fig. 1 applied to ordinary 40 watt lamps. On page 591 we are given to understand that this same figure represents data obtained on the new rapid start lamps. If these same curves are equally applicable to both types of lamp, why do the numerous objections and difficulties recited in regard to starting aids and cathode heating in the case of standard lamps not apply with equal force to the new lamps?

(5) Is it not a fact that the use of a grounded fixture and a water repellent coating on the lamps are the features which assure satisfactory starting at high humidities with reasonable voltages? If so, what new features are involved? Grounded metal fixtures have been recommended for years. Water repellent coatings to eliminate the adverse effects of high humidity on starting were introduced commercially some six or seven years ago.

(6) Is it not a fact that the chief — if not the *only* — purpose of the new low resistance cathode coil is to reduce the heating power necessary to properly operate these cathodes?

(7) The only two lamp circuit which the authors discuss is the lead-lag arrangement shown in D of Fig. 5. The ballast recently made commercially available by their company is a series sequence type. Some information on the relative merits of the two types would certainly be of considerable interest, particularly in view of the fact that series operation of fluorescent lamps has several obvious disadvantages.

At this point I would like to make it perfectly clear that I have nothing against the general idea behind this so called rapid start operation of fluorescent lamps. On the contrary, I have been in favor of this method of operation ever since 1939 when I used the same circuit arrangement shown in A of Fig. 3 to operate fluorescent lamps and a similar circuit to start and operate two lamps in series. Others have also employed similar circuits at one time or another.

Let me say then — that there are many advantages to this method of operation. Several of these have been indicated by the authors. However, there are also disadvantages which all should recognize. There is not time to discuss them all but I would like to mention one of the most important. That is the matter of contact resistance. The filamentary cathode which we are discussing here has a hot resistance of about 9 ohms. Suppose an additional resistance of the order of 5 ohms is inserted, by poor mechanical contact, pin or socket corrosion or by some other mischance, then the effective resistance of the filament will be increased to 14 ohms and the heating current reduced from 380 ma to 250 ma. This is the region where unreliable starting is to be expected. Tests in our laboratories have shown that this is exactly what we may expect. Actually, there has been difficulty in the field with trigger start operation of circular lamps using 12 14-volt filament windings for this reason.

There are other difficulties to be overcome such as proper and positive grounding of both the transformer and the metallic reflector.

There is no doubt that these and other problems will be solved. When these objectives have been accomplished, we have before us an excellent method of fluorescent operation.

E. H. Salter*: Again, I am intrigued by the presentation of a new lamp and a new ballast. And again, a comparison of the new with the old would serve to evaluate the progress that has been made.

There is an age-old saying to the effect that we really know little about a given device or characteristic of a device until we can measure it or measure its effect. The authors state that: "It is extremely difficult to measure lamp watts with any certainty in such a circuit." I believe that I might add that it is extremely difficult to measure lamp watts with any certainty in any discharge lamp circuit. It has taken nearly 15 years to reach that conclusion, but I am sure that those who are close to this problem will agree with my statement.

Nevertheless those working with fluorescent lamps have been making measurements of what has been called lamp watts. Such measurements make it possible to assign intrinsic efficiency values to the lamps alone and to evaluate the performance of ballasts as such. In fact, specifications are written around those measurements. The difficulty of measurement is acknowledged.

Now we are told by the authors that: "Because of this we prefer to measure input watts and lumen output." I will grant that these measurements should serve to indicate what the user will have to pay for in the way of electrical energy used and what he will receive in light output. Nevertheless, I enter a plea that an all-out effort be made to develop or establish a means of reliably measuring the watts delivered to the lamp by the ballast so that lamp efficiency and ballast effectiveness may be evaluated independently.

R. D. Bradley*: Perhaps it is not widely recognized that today there are at least seven ballasting circuits in common usage, these circuits all pertaining to multiple lamp operation. Very recently there has been another ballast and circuit added, namely the rapid-start circuit for lead-lag operation.

In doing some experimental testing on the rapid-start lead-lag ballast, it was discovered that starting was very erratic when the fixture was ungrounded.

I assume that this problem has been considered by the designers and manufacturers of this ballast and that there are some definite reasons for its use. I would greatly appreciate the authors touching on this subject.

W. P. Lowell**: At the I.E.S. Conference in Washington last year, a paper was presented by Hinman, Keiffer and Streeker† which provided the necessary data to help clear up a most unfortunate industry situation, namely, the trouble which had been encountered with the series sequence ballast. In discussion on that paper, I suggested that the entire lighting industry should learn a lesson from that experience and that we should not jump too fast into untried fluorescent ballast circuits. The same comment applies here.

This ballast circuit appears to have considerable merit, but our customers must recognize at least the following four items:

(1) It will now be necessary for manufacturers, wholesalers and some consumers and dealers to stock 48 kinds of a "40-watt" lamp (4 lamp styles multiplied by 12 colors).

(2) The consumer must be *sure* that he is using the

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*Day-Brite Lighting, Inc., St. Louis, Mo.
**Lighting Division, Sylvania Electric Products Inc., Salem, Mass.
†Published October 1951 issue, ILLUMINATING ENGINEERING, pp. 560-566.

proper lamp; otherwise, lamp trouble or ballast trouble will develop.

(3) Luminaire manufacturer and consumer must insist that the ballast have high enough open circuit voltage *and* a grounded ballast can and fixture *and* a reflector or other grounded metal must be within one inch of the lamp to aid in proper starting.

(4) Most important — all electrical joints must be good ones and all lampholder and lamp contacts must be kept clean, because the addition of even a slight resistance anywhere in the filament heater circuit will result in non-starting of lamps and may possibly damage the lamps.

W. H. KAHLER*: The authors state that the fixtures employing rapid start lamps must be grounded. The writer understands that a grounded component of the fixture must be parallel to the lamp within a distance of one inch. Is this the case? If so, it imposes definite design limitations on equipment for four or more lamps. There is a definite trend toward all-plastic shielding on fixtures and the outer lamps on four-lamp equipment may be six inches or more from the center channel which would be the grounded component. Do the authors have any suggestions in the way of lamp or ballast design that would eliminate this design limitation?

It is also recommended by the authors that a series type of two-lamp ballast will produce the most reliable starting. The elimination of starters is a step toward easier fluorescent maintenance but series ballasts complicate the maintenance problem. With the series type of ballast, the maintenance man cannot readily determine which lamp should be replaced when one lamp reaches end of life. Experience with series slimline ballasts has emphasized this difficulty. Therefore, I hope that the ultimate design of ballasts established in the industry will be of the lead-lag type for rapid start lamps.

W. W. BROOKS**: We are particularly fortunate to have heard of the several years of experience in Great Britain with an instant-start circuit which is very similar to our rapid-start circuit.

Dr. Aldington stated that, because of the high line voltage, no voltage step-up is necessary in the ballast. This point is salient when the practice in Great Britain is compared with the rapid-start circuit. In the circuit used in Great Britain it was necessary to incorporate a separate transformer to supply cathode heating current. This arrangement, without further complication, automatically reduced the cathode heating current after the lamp started. Therefore, it was possible and practical to use lamps with standard cathodes. However, with voltages in common use in the United States the cathode heating current could not be reduced after the lamp started without complicating the ballast circuit.

Mr. Bachman has correctly indicated that it would be possible for anyone servicing a rapid-start fixture to insert a 48-inch bipin, instant-start lamp in the lampholders, despite the fact that "rapid start" is clearly marked on the lamp.

That problem has been investigated. We have found that properly designed rapid-start ballasts will not fail even after prolonged operation with instant-start lamps.

Furthermore, the ballasts have been submitted to Underwriters' Laboratories, Inc. and Underwriters' Laboratories, Inc. has ruled that the ballasts are not a fire hazard when operating instant-start lamps.

Mr. Hjermstad has very ably indicated some of the effects on ballast design which may be brought about by the development of the rapid-start lamp. The circuits which provide constant cathode heating current were not included in the paper because of space limitations.

The comments by Mr. Salter point up a very perplexing problem connected with the rapid-start circuit. We can assure him that we are aware of the need for a means of reliably measuring the watts delivered to the lamp by the ballast, and we will continue to work on the development of such a means.

A. E. LEMMERS*: As I listened to Dr. J. N. Aldington discuss this paper I was moved by both satisfaction and I must also confess some envy. Satisfaction in the successful application of similar principles of lamp starting in England which he referred to and which confirms my results, and envy that the distribution systems and other conditions of his country so favored the application of these principles that they could proceed to commercialization so rapidly.

Dr. Aldington and Dr. Lowry have made reference to an embryonic form of the rapid-start system. The system used in Britain, while comparable, is not applicable to general lighting in this country. A short history of this development will help in understanding the differences.

In 1939 at the New York World Fair among the groups of fluorescent lamps installed was one group of ten lamps which were started by use of cathodes being preheated in conjunction with a starting aid. The starting aid was a platinized stripe on the 18T8 bulb. The cathode heat was furnished by heater coils coupled to a choke in a resonant circuit. The resonant circuit raised the 118 supply voltage to a starting voltage and furnished cathode heat until the lamp started and then fell out of resonance. This ballast just could not compete with the switch-start ballasts as they were developed. It was too far out of line in size, weight and cost. In addition we had found at this early date that lamp life was damaged on such a ballast because of frequent instant starting without waiting for cathode heat, due to switching transients producing a higher voltage.

Through the war years our attention was on other matters but in 1945 I again started work on this type of starting of fluorescent lamps. The elimination of the uneconomical ballast bulk and the improvement of lamp performance when these principles were applied to our 118-volt systems were the major problems.

It is this difference in distribution systems which accounts for our need of the new cathode. When lamps are operated from supply sources of sufficient voltage so that no step-up is used, instant starting due to transient surges at switching in and above normal peak to rms voltage from transformers, is avoided.

I have found no way of circumventing these conditions in the step-up type of ballast without undue increase in ballast cost. However, the new cathode has much greater tolerance to instant starting than the older cathode. One of the several functions of the new cathode is its ability to deliver nominal life even when there is an appreciable degree of instant starting present.

Among comments of Mr. Hardacre is a very accurate

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**Co-author. (See also rebuttal by A. E. Lemmers, starting in next column.)

*Co-author. (See also rebuttal by W. W. Brooks, starting in previous column.)

prophecy as to the extending of these rapid start principles to larger wattage lamps. You probably noted I mentioned in this presentation the extension of rapid start to the new 100 watt 72T12 lamp which our Lighting and Rectifier Division is making excellent use of in their new street lighting fixture.

I am quite certain Mr. Bachman has based his conclusions of non starting at 106 volts on entirely too small a sampling of lamps. Unfortunately I also suspect he has obtained some lamps of very early manufacture which might be troubled with residual gas as shown in Fig. 2. If the non starting is for the first start only as reported by Mr. Bachman to one of my associates, this certainly is the case. A few minutes of burning would permanently cure the starting difficulty at minimum line volts. Lamp quality is not affected. No starting trouble at normal line volts is involved. A few more minutes seasoning at the factory eliminates the condition. Under these circumstances a reduction of gas filling pressure would have little effect.

I would like to remark here that if we insisted on starting under all adverse starting conditions taken at the same time, we would hardly ship any standard instant start lamps. Yet we have sold these lamps for many years with negligible complaints on starting. The same will be true I am quite sure for the rapid start lamps. Tests have been obtained which show the rapid start lamps to have a greater percentage starting at low line volts under adverse conditions than did the instant start lamps.

Although I reply to others on this question of resistance in the cathode heater circuit I must remark that Mr. Bachman has mentioned the only two points of connection in the circuit which ever cause trouble. We very early detected these trouble sources and corrected them. They are the cathode to lead connections and the lead to base pin connection. We use a certain soft inner lead which cures the first possible trouble and a crimped pin which eliminates the second.

Mr. Brooks, I believe, has answered the lamp interchangeability question as regards to ballast damage.

As so many ask for rapid start series versus lead lag comparison I will give it for all at the end of these comments.

In reply to H. U. Hjermstad, no damage occurs to the remaining lamp in the rapid start series ballast when lamp #2 fails even though it remains in the low current condition for many many hours.

Dr. Lowry has presented us a list of questions. It is certainly very helpful and I will attempt to answer them to his satisfaction.

(1) Curve C, Fig. 1 is actually for a connected stripe lamp. It was referred to in the text as approximating the condition for a lamp on a grounded fixture. This is so as we consider the differences between curves C and D to be insignificant. However, it is the authors' fault for not being more explicit. Fig. 1 was originally two figures which were combined.

(2) I believe the text is clear that the comparisons of damage due to instant starting were for ordinary preheat type lamps. The way out of the dilemma was to change the lamp cathode to a type that would tolerate instant starting. The rapid start lamps with the new cathode have shown on instant start test to equal the instant start lamps if the pins are shorted.

(3) Inasmuch as Dr. Lowry has stated the conditions with 100 per cent accuracy, I am at a loss to understand why he is confused. This section of the paper deals with ordinary lamps. The condition (a) as listed by Dr. Lowry is the present trigger ballast. It operates regular lamps. Regular life tests for the past several years yield the results given. Condition (b) was never offered to the public because of the frequent non starting due to humidity.

(4) The answer to question 1 has partially answered this. Curve A and Curve D under *low humidity* are the only curves that apply to regular lamps. All the other curves are described in the text as lamps specially equipped with starting aids.

(5) One of the new features is a starting voltage over 40 per cent less than heretofore obtained. It is obtained by having cathode heat in addition to the water repellent bulb and a grounded fixture. Curve D most effectively shows this where the extreme left portion of the curve is applicable to lamps operated as Dr. Lowry suggests and the right hand portion is representative of rapid start. The text also mentions life damage to lamps started as indicated on the left side of the curve and normal life for starting as indicated on the right hand side of the curve.

(6) The new low resistance cathode has several major functions. Each feature, however, has a specific purpose and all taken together give us a superior cathode more nearly universal than any previously available. Any of the previously available cathodes may be shortened to make for low resistance but life is also shortened. The proportioning geometry and coiling of this cathode which, while not fully covered in the paper, but which I showed and discussed in the presentation at the Conference, constitute one of the best ways to achieve full life at rated current yet having low resistance.

(7) As several have asked a similar question I will give later a comparison of the series versus lead-lag rapid start ballast.

Dr. Lowry points out that resistance in the cathode heater circuits may cause non starting and as an example uses a value of 5 ohms.

We certainly are in the "Dark Ages" of Electrical Engineering if we are unable to make connective devices which for currents less than one ampere have resistances in the order of ohms. Although I must admit that my measurements and experience are limited to the various types of sockets made by one manufacturer I find that the usual contact resistance is in the order of hundredths of an ohm. One exceptional case was found wherein a socket mounted on a board standing on end and stored for over a year in a corner of a laboratory showed upon use a temporary resistance of about 1 ohm. This socket through the year had been dirtied by scrub water probably several times and was quite dirty and corroded and probably coated with detergents. The fact that it had an abnormal resistance was only noted because upon use in a circuit with meters it was observed that the heater current to that socket was .040 amperes less than to the adjacent socket. Turning the lamp twice in the socket caused the resistance to permanently disappear. Now this temporary resistance of approximately one ohm did not inhibit lamp starting at normal line volts at all. If we take the lowest line voltage and a ballast at the lowest permissible open circuit voltage we can tolerate as much as 0.5 ohms resistance and still start the lamp. This is a resistance about ten times what is ordinarily experienced. In the thousands of lamps we have handled in testing this general type of circuit in the past seven years we have never experienced difficulty with resistance in the

socket as long as the lamps were actually in the socket. Service tests in places of abnormal humidities, vapors, and vibration have shown no trouble. We have, however, experienced difficulty in the cathode heater circuit which we corrected more than a year ago. I refer to the connection of the outer lead of the lamp to the pin of the base. In the past these have always been soldered. We have found, however, that in mass production there are short periods of manufacture when due to various circumstances high resistance solder jobs may be produced. Although external appearance is good and immediate contact is good, these particular solder jobs may develop into a poor contact with time. You will note that the rapid start lamp as made by us has what we call a crimped pin. This type of connection has never shown a high resistance contact with many sampling measurements from several million bases. The field difficulty mentioned by Dr. Lowry on trigger start operation of circular lamps at least in our lamps was traced solely to poor solder due to an iron outer lead used because of metal emergency supply conditions.

In view of the fact that millions of radio tubes using even lower cathode heater voltage than the rapid start lamp have been in service for many years, I am just slightly puzzled why Dr. Lowry should become so concerned. Certainly the engineers in the lighting industry have designed as well as those in the radio industry. The cathode heater circuit of the rapid start lamp is essentially the same as for vacuum tubes.

In reply to Mr. Bradley, so many have asked for lead-lag versus series rapid-start information that I will cover this at the end of the discussion.

Mr. Lowell's comment about jumping into untried ballast circuits is quite to the point. For that very reason we have spent the last two and a half years of this development in testing the ballasts and lamps we are offering the public today. There have been hundreds of lamps on life and service tests and thousands of lamps handled in various other types of testing such as starting under abnormal humidity, temperature, fixture combinations, storage effects, etc. We have tested this product longer than any fluorescent lamp we previously brought out. We know of no major difficulties with the lamp or ballast as we offer it.

(1) It is my opinion that while for the present the kinds of lamps stocked have been increased, eventually this lamp will be used in all circuits.

(2) This statement is only partially true.

For example the rapid-start lamp can be placed in switch-start sockets and in all probabilities the consumer would get normal service.

If placed in instant-start sockets the same results would be had as though a regular preheat-start lamp had been inserted.

If switch-start lamps are placed in rapid-start sockets, starting is only possible with full supply volts and low humidity.

If instant-start lamps are put in rapid-start sockets they do not start at all. If left in position with power on, no ballast damage results in many hours.

(3) The voltages in the G.E. ballasts have ample safety factor and the values have been given to the industry. Where necessary the G.E. ballasts provide the conditions essential for operation even with an ungrounded fixture. The reply to W. H. Kahler covers the fixture problem.

(4) I have been under the impression that good electrical connections have for many years been common practice. As far as a slight resistance is concerned it apparently means different values to Mr. Lowell than to myself. I consider half an ohm in a supposed good connection to be large. Measurements indicate values less than one tenth of this. Service tests indicate the same. Our British friends' experience as reported by Dr. Aldington, indicates likewise and our own radio experience concurs.

Mr. Kahler is correct in the assumption that, for reliable starting over the range of humidity and temperature usually specified for fluorescent lamps, the fixture should be grounded and should be at least within one inch of the lamp. The authors, however, have some very definite suggestions for operation of four-lamp fixtures which with plastic shielding may make the above requirement difficult to meet.

(1) Do not use single-lamp ballast on multiple fixtures.

(2) If lead-lag ballasts must be used good results can be had if the lead lamps are mounted next to the fixture and the lag lamps in the outer positions. With lamps on three-inch centers or less the lead lamps will always light and act as a starting aid for the lag lamps.

(3) With a series ballast there is no problem, however, the lowest starting volts may be had by placing the capacitor shunted lamp on the outside (red lead).

The above have been proven by test on General Electric components only.

Maintenance of rapid-start series ballasts has never presented any difficulty in the two and a half years it has been under test. I have always found the failed lamp to be the one with a very dark end. It is of such an appearance that it can be seen by a casual look before climbing up to change lamps. Because several have asked for a comparison of the rapid-start series and lead-lag ballasts I will answer this later.

Rapid-Start Series To Lead-Lag Comparison

An explanation of the part played by the starting aid in starting lamps will help in understanding some of the results that follow. If the starting aid has a potential of approximately 150 volts or more in relation to one of the lamp cathodes, a feeble glow will be initiated between the cathode and starting aid as soon as the cathode warms. By cumulative ionization this grows to full current if the potential between the starting aid and electrode is great enough. If this potential between starting aid and electrode is less than 150 volts, no starting occurs unless the potential across the lamp is so high that instant starting occurs. Under such a condition the ballast loss would be up and cathode heating is superfluous. This value of 150 volts between electrode and aid is approximately the value needed for argon-filled lamps regardless of length.

In lead-lag and single-lamp ballasts about 225 volts are across the lamp electrodes. All that limits the current through the lamp after the glow current is established is the lamp and ballast effective resistance. Thus starting is characterized by a very brief interval in which the electrodes heat, then glow is established, followed by a very quick shift to full current. Tests on many lamps yield an average starting time to full current of about 30 cycles.

In the series ballast about 285 volts are across two lamps. One lamp is by-passed with a small capacitor. Here at zero current practically 285 volts are across the lamp that is not by-passed. Even if the cathodes are cold, a glow is established but the current is limited to less than 1 ma. This low current produces no damage, as it is so low, and the

cathode is large enough to take it as a cold cathode glow without blackening or damage. As the cathode, however, heats up due to current from the heater circuit, the cathode fall drops and the current through the by pass capacitor and thus the voltage across it rises until it is high enough to start the glow in the second lamp. This usually happens before the cathodes are at full temperature and although the current increases, it does not get to full value until the cathode fall has been reduced to 20 volts or less. Until this happens the lamps' resistance plus the ballasts' reactance hold the current down as there is only about 143 volts per lamp available and lamp voltage is but little less.

This causes a start characterized by practically instantaneous light at a low level which rapidly builds to full brightness. Average time is from about 45 to 100 cycles from closing the switch to full current. Many people have expressed a preference for this starting as it produces less visual shock.

Because of the conditions described, the series rapid start ballast is less dependent upon a starting aid than the lead lag rapid start. The lead lag should insure fixture grounding with a resistor from white lead to case of about 2 megohms. When the ballasts are served from ungrounded systems such as a three phase delta, a grounding of the phase serving the black ballast lead puts the lead lag ballast in a non starting condition because less than 150 volts will be between the high potential cathode and the grounded starting aid. The line voltage has been subtracted from the total. In the series ballast, no matter which side of the primary is grounded, there is still more than 150 volts between the starting aid and cathode.

When I speak of 150 volts for this condition, please keep in mind I mean an rms voltage with essentially a sine wave. As the peak to rms is made greater the value of voltage needed decreases. In the lead lag ballast we must avoid a high peak to rms. If we get a high enough peak we initiate glow before the cathodes are hot and lamp resistance and ballast reactance are insufficient to hold the current low enough to prevent destructive cathode fall. In other words instant starting occurs to a damaging degree. This result has long been observed even on preheat switch start ballasts. The series ballast on the other hand is hardly affected by high peak volts, as the by pass capacitor and ratio of lamp to ballast volts hold the current in check so that the cathodes are heated in the main by current conduction and not by ion bombardment.

We have tested both types for about two and a half years. We did not market the lead lag because of its inability in the 40 watt lamp size to cope with conditions on ungrounded systems. We understand a large part of the industry is so served. If the lead lag is modified to take care of this situation for 40 watt lamps, one only gets into shorter life and more ballast loss. For higher voltage lamps, however, lead lag ballasts do not have this difficulty.

Our tests have shown strobe, maintenance, and outage of two lamps at once to be, in my opinion, mostly imaginary flaws. J. H. Campbell has shown strobe to be of no consequence under usual conditions. If a man can see an all black end on a lamp he can find the failed lamp. If two lamps go out you lose about 5,000 lumens. With an incandescent installation which is still not unusual for high level lighting, one 300 watt lamp outage produces the equivalent lumen loss. This loss of lumens then is not an unusual situation.

If, as lighting engineers, we are sincerely interested to reducing the ballast losses and thus improving the lighting economics, the series rapid start ballast offers us the best opportunity I know of. We can use it without any loss of life or potential damage to ballast if failed lamps are not quickly removed. Life is such that, in my opinion, group replacement can be used most effectively. The percentage of failed lamps at replacement time will be much smaller than with other systems.

My own feelings are that we should not stop at two lamps in series. Three and even four can do a better job. You will recall that in the presentation I showed a four lamp series circuit and mentioned that the ballast loss was about 12 per cent of the lamp load. This is an improvement of more than 50 per cent in cutting ballast loss and can be even more in the ballast cost per lamp.

In conclusion we wish to thank each gentleman for his interest, time and effort in presenting a discussion on our paper. It is evident that most are quite enthusiastic about the rapid start lamp and ballast. A few believe it to be a good general scheme but have some doubts as to whether certain features may not cause trouble under some conditions. To these latter I hope our answers to their questions have resolved their doubts. In addition to our answers, mayhap the comments of Dr. Aldington on the superbly satisfactory experience in Britain of a comparable "System" may have allayed their fears. If not, I am sure that a little more personal experience will better acquaint them with the benefits to be derived from the new lamps and ballasts.

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The official emblem of the Illuminating Engineering Society is available to members in 14-karat gold, lapel screw back buttons, in the miniature ½" size, at only $3.50 each including taxes. Blue background for Members, red background for Associate Members. Order from Illuminating Engineering Society, General Office, 1860 Broadway, New York 23, N. Y.

Simple Sign Makes Sense

By WILLIAM G. DARLEY

AIR CONDITIONING leads to closed doors. Closed doors lead to signs saying "OPEN" on one side and "CLOSED" on the other. While it is theoretically a simple matter to keep such signs turned for the proper indication, they are usually a nuisance and end up permanently fixed to display the word "OPEN." This leads to confusion when they should read "CLOSED." The sign herein described, which takes care of this problem with the flip of a switch, is an Electrical Engineer's solution.

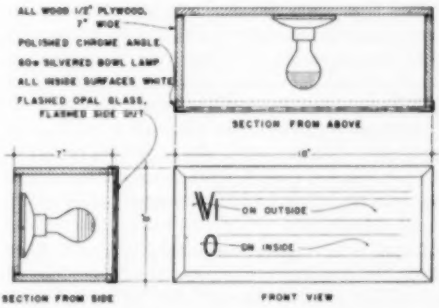
The dimensions of the sign housing are such that all five of the ½" thick plywood panels forming it are the same width (7" for the sign shown). While this fixes the height and depth of the housing, it leaves its length variable. The advantage of the common width for the panels is that it makes it simple to buy the wood since it is necessary to order only one piece of ½" plywood of a length equal to three times the desired length of the sign plus 2 x (selected width − ½").

The sign is mounted with one wood screw. Instead of being mounted with the face in the vertical plane, it is tilted forward at the top so that it is more nearly perpendicular to the line of sight of observers entering the hallway in which it is located.

Flashed opal glass is installed in the housing with the flashed side out. The name is lettered in black on the flashed (out) side of the glass. Thus the name is plainly visible whether the sign is lighted or not (Figs. 1A and 1B). The legend "OPEN — COME IN" is lettered in black on the clear (in) side of the glass. Thus when the sign is "off" the visibility of this legend is of a low order (Fig. 1A); however, when the sign is "on" the "OPEN — COME IN" is plainly visible (Fig. 1B).

It is highly probable that a better effect could be produced since the legend is a bit fuzzy around the edges. For instance, the material intended to be read only when the sign is lighted could be lettered on the glass using an opaque paint having a reflection factor approaching that of the flashed opal. In this case, the effect would probably be better with the flashed side inside or with the lettering on the outside.

An interesting feature of the sign is the high degree of uniformity of the brightness of the glass panel. The key to this is the use of a silvered bowl lamp, which type of lamp inherently has a flux distribution which fits it almost perfectly to the application. The distribution of the lamp is complemented by the white finish of the box interior.



AUTHOR: Consulting Engineer, Austin, Texas.

Figure 1A. Sign unlighted.

Figure 1B. Sign lighted.

Brightness Discrimination Data for The Specification of Quantity of Illumination

By H. RICHARD BLACKWELL

Introduction

ONE OF THE BASES for specifying quantity of illumination is visual performance. For example, Report No. 5 of the Committee on Standards of Quality and Quantity for Interior Illumination of the Illuminating Engineering Society[1] is devoted to this approach to the problem of quantity of illumination. The primary experimental data upon which Report No. 5 is based are those of Weston. This investigator determined the speed and accuracy of visual performance involving identification of the orientation of Landolt broken rings for each of a number of illumination levels. The subjects were required to identify all rings with breaks in a given orientation from among a large collection of rings. The proportion of rings correctly identified was used as the accuracy score. Speed was measured by the inverse time required to perform the visual task, allowance having been made for the time required for the mechanical manipulations. The simple product of speed and accuracy was taken as a measure of "performance." Weston expressed his data at each illumination level as a proportion of the maximum "performance" which was obtained at the highest illumination studied. The size of the breaks in the Landolt rings and the brightness contrasts between the rings and their background were varied in different experiments.

The Weston data are generally conceded to be useful for specifying the quantity of illumination. The data were obtained with this particular objective in mind, unlike many sets of visual data which might be employed for this purpose. The visual task demanded of the subjects seems representative of visual tasks which may be required of workers in practical situations.

The principal shortcoming of the data is the ambiguity of the measure of "performance" which Weston has used. As we shall see, speed and accuracy each bear complex relations to the quantity of illumination. A simple product of speed and accuracy indices will therefore depend upon each of the constituent indices to a different extent at different illumination levels. Thus, increments of "performance" represent increases in either speed or accuracy or both, in indeterminate amounts. This means that one per cent increments of relative "performance" may be very unequal in their visual significance and that the use of "performance" levels may be very misleading. The only completely unambiguous procedure is to specify speed and accuracy separately so that the illuminating engineer can ascertain the extent to which each of these aspects of visual performance increases as the quantity of illumination is increased.

There is abundant experimental evidence revealing that different visual tasks require different levels of illumination. Thus, specification of the quantity of illumination for a particular lighting installation requires diagnosis of the visual task involved and application of appropriate visual performance data. It is here proposed that ultimately the specification of quantity of illumination from performance data should be based upon systematic data representing the relations between speed and accuracy and illumination for various *fundamental* visual tasks. Once such a body of data exists, the illuminating engineer need only develop a method for diagnosing the appropriate set of data for *fundamental* visual tasks to apply to the actual visual task at hand. At the time of writing, it seems likely that satisfactory methods of diagnosis of visual tasks will be developed, in the form of visibility or contrast meters.

The present paper reports a set of experimental data which were collected to provide a basis for specifying the quantity of illumination, when the visual task is that of discriminating brightness differences. Separate measures of speed and accuracy of brightness discrimination have been obtained for each of a number of illumination levels. Methods are suggested for utilizing these data to specify the necessary quantity of illumination for various levels of speed and accuracy.

Apparatus and Procedures

The experimental data to be reported here have been described elsewhere in detail[2] so that a com-

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paratively brief description of the apparatus and procedures will suffice.

The basic experimental task of the subjects was to detect the presence of a disc target which was produced by adding a brightness increment to a small portion of a screen of uniform brightness. The screen constituted an inner wall of a cube whose dimensions were approximately 7 feet on a side. Walls of the cube were coated with sphere paint. The subjects were situated 10.25 feet from the screen. The screen of uniform brightness thus subtended approximately 40 degrees at the eyes of the subjects. Other walls of the cube were also visible which were nearly as bright as the screen. These walls extended the visual field of approximate uniformity to at least 60 degrees in every direction. The subjects used normal binocular vision with natural pupils. Two subjects were employed throughout, who observed together.

Light sources for the illumination of the screen were incandescent lamps placed at the rear of the cube near the subjects, but completely shielded from their view. The number and wattage of the lamps was varied to adjust the quantity of illumination falling upon the screen. In order to insure uniformity of brightness of the screen, direct illumination from the lamps was shielded. The apparent color temperature of the screen brightness was 2850K.

The target was produced by transillumination of a milk-plastic screen which served as the major portion of the screen wall. Size of the target was determined by the physical size of the aperture through which the beam transilluminated the plastic screen. The aperture was pressed tightly against the rear surface of the plastic. The plastic was paper-thin. Consequently, the definition of the edge of the target was excellent. Four target sizes were employed subtending 1, 4, 16 and 64 minutes of arc at the subjects' eyes.

The target brightness was produced by a high-output projection system based upon a special ribbon-filament lamp kindly made available by the General Electric Company.

The target always appeared in a known location in the center of the screen. The subjects utilized four bright points which were arranged in a diamond pattern for fixation and orientation purposes. The four points were arranged symmetrically about the target. The separations of the fixation and orientation points were determined on the basis of preliminary experiments so that the target was maximally discriminable at all times. The separations among the fixation points varied from 18 minutes in the case of the smallest target to 40 minutes in the case of the largest target. In each case, the subjects fixated the center of the configuration of fixation points. Thus, all the data refer to central foveal vision. The intensity of the fixation points was adjusted to approximately ten times their brightness difference threshold. Previous experiments reported elsewhere[2] indicated that fixation lights of this intensity will have minimum influence upon the discriminability of nearby targets.

The subjects were not allowed to judge directly whether or not they detected the presence of the target. They were required to prove their ability to detect its presence by correctly identifying the time interval of four possible intervals in which the target occurred. The temporal intervals were each 2.5 seconds long. Following the four intervals, the subjects were given 8 seconds in which to select the temporal interval they considered the target had occupied and to record their choice by depressing one of four response buttons. The subjects then had 2 seconds in which to prepare themselves for the next presentation of the target.

It has been shown elsewhere[3] that requiring subjects to prove that they can discriminate is distinctly preferable to accepting their own direct evaluation of their ability to discriminate. The data obtained under the former conditions are both more reliable and more valid.

Each experimental session consisted of 250 target presentations, 50 at each of five target brightness increments intended to elicit from nearly zero to nearly 100 per cent correct discrimination. Each experimental session was divided into five sub-sessions, each of which contained 10 presentations of each of the five target brightness increment values. Each sub-session lasted about 17 minutes. At the end of each sub-session, the subjects were allowed a 5-10 minute rest and relation period. The entire experimental session lasted nearly 2 hours.

The presentation of the targets and the recording of responses was facilitated by automatic equipment described elsewhere.[2] Briefly, the schedule for presentation of targets was governed by coded holes in a paper tape. The holes excited appropriate metal roller contacts, which activated electrically controlled projection apparatus through mediation of a relay panel. The timing of all stimulus presentations depended upon a synchronous motor and a system of cam contacts situated on the drive shaft of the motor. The magnitude of the target brightness increment was varied by a filter-selector device which could intersperse one or another Wratten neutral filter in the projection beam. The interval occupied by the target could be varied by operating a shutter at one of four possible times. "Verification" equipment was provided, so that the accuracy of the electrical components in providing the desired stimulus conditions could be established.

The stimulus conditions for each presentation

and the temporal interval selected by each subject were recorded automatically. The recorder was composed of 28 solenoid-driven precision punches which made coded holes in a lightweight cardboard record sheet.

The correctness of the selection made by each subject on each presentation was established by series relays and recorded by means of a bank of electric counters. One counter recorded the number of correct selections made by each subject for each target brightness increment.

In the rare event that the electrical components failed to provide the stimulus conditions required by the tape, all record of the presentation was automatically eliminated.

The basic data from each experimental session were proportions of correct answers for each subject, at each of the five target brightness increments. There is, of course, a probability of .25 that the subject will get the correct answer by chance alone. The effect of chance successes may be eliminated by the formula:

$$p' = \frac{p - .25}{.75} \qquad (1)$$

where p = raw proportion
p' = corrected proportion

Throughout the remainder of this paper, we will refer exclusively to values of p' as defined by equation (1).

The duration of the target presentation was given seven different values in different experiments: 1, 1/3, 1/10, 1/30, 1/100, 1/300, and 1/1000 seconds. Control of the target duration depended upon a large metal disc which rotated in the projection beam. The target was presented whenever an aperture in the disc was aligned with the projection beam. The size of the aperture was continuously variable. The time required for the target to increase to full brightness was always a negligible fraction of the target duration.

The two subjects whose data are reported here were graduate students at the University of Michigan, specializing in sensory psychology. One was male, the other female. The subjects were unusually interested in the experiments. Their visual acuity was known to exceed 20/20. Two other subjects were used for a portion of the same experiments. These subjects were undergraduates whose interest in the experiments was reasonably great but not exceptional as was the interest of the graduate students. As is reported elsewhere,[2] the data from all four subjects appear to be very similar. Only the data for the two graduate student subjects are presented here since only these subjects observed under all the experimental conditions.

Photometry of the screen brightnesses was performed directly with a Macbeth Illuminometer, fitted with a lens attachment to image the screen in the Macbeth cube. Photometry of the two largest targets was accomplished in a similar manner. Photometry of the two smallest targets was accomplished by what might be called a "candlepower box." A closed metal box was made with an opal disc at one end and a small aperture at the other. The aperture was fitted snugly against the screen so that the transilluminated target lay entirely within it. The target thus became a source for illumination of the opal disc at the other end of the box. Baffles were placed within the box to eliminate interreflections. The brightness of the opal disc was measured routinely with the Macbeth. From the transmission of the opal disc and the inverse square law, the intensity of the transilluminated target could be determined. From known size of the transilluminated target, the brightness of the target could be computed. Two "candlepower boxes" were used, one for each of the two smallest targets.

The target brightness increment was adjusted to the appropriate value for each experimental condition by means of Wratten gelatin filters placed in the projection beam. The transmissions of these filters were determined on an optical bench photometer. The calibration of all photometric instruments depended upon lamp and test-plate standardizations made by the Electrical Testing Laboratories of New York.

Results

In all, 162 experimental sessions were conducted in which background illumination, target size and duration were varied, in each of which brightness discrimination was measured.

We may well begin by considering the basic form of the data obtained by each subject in a single experimental session. The basic data are proportions of correct discriminations, after correction for chance successes, and the contrast between target and background, defined as follows:

$$\text{Contrast} = \frac{\Delta B}{B}$$

where ΔB = brightness increment of the target
B = brightness of the screen in the absence of the target.

The proportions of discrimination give us a direct measure of the *accuracy* of brightness discrimination.

In Fig. 1 we have exhibited a theoretical curve which has been found to adequately represent the experimental data of all the present experiments. We note that the probability of discrimination increases in a sigmoid fashion as the contrast of the target increases. The theoretical curve is a normal ogive, the integral of a normal frequency distribu-

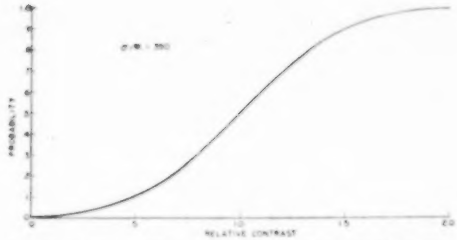

Figure 1. The relation between probability of brightness discrimination and target contrast found in all the experimental data. The curve is an integral of a normal frequency distribution, with parameter values: $M = 1$ and $\sigma = .390$.

tion. Our data analysis procedure involves determining the particular ogive which best fits the five experimental points obtained by each subject in each experiment. The ogive varies in two parameters, designated M and σ. The value of M is usually called the threshold; it is the target contrast at which $p' = .50$. The value of σ measures the steepness of the ogive. Sigma is actually the standard deviation of the normal distribution from which the ogive is obtained by integration. When σ is large, the ogive is flat.

As is indicated elsewhere,[2] the most appropriate ogive is determined for each set of experimental data by a procedure called the *probit analysis*. This procedure gives us values of M and σ for the ogive which best fits each set of data and also provides us with a measure of the goodness of fit of the experimental data to the theoretical curve. Curve fits for all the present data were entirely acceptable.

Values of M varied over a million to one as illumination level, target size, and target duration were varied. Preliminary examination of the experimental data revealed the existence of a simple relation between M and σ, as M varied over this tremendous range. Values of M and σ were directly proportional, that is $\sigma/M =$ constant. There is considerable evidence for this relation in earlier experiments, as is indicated elsewhere.[4] As we shall see, the existence of this simple relation between M and σ enormously simplifies the problem of reporting and using the present experimental data.

TABLE I.—Average Values of σ/M

Target Size (Minutes of arc)							
	1		4		16		64
	.373		.417		.396		.385
B (footlamberts)							
.001	.1	.3	1	3	10	30	100
.419	.421	.389	.386	.387	.380	.374	.355
Duration (seconds)							
1	1/3	1/10	1/30	1/100	1/300	1/1000	
.485	.450	.374	.370	.361	.361	.332	

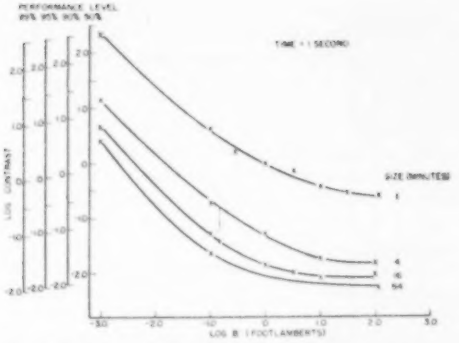

Figure 2. Data obtained with a time of exposure of 1 second. Each point represents at least 500 responses by two subjects.

The average values of σ/M for all the experimental data were .384 for one subject and .396 for the other. The theoretical curve in Fig. 1 represents $\sigma/M = .390$, the average value for the two subjects.

We have obtained average values of σ/M for both subjects in terms of each of the three experimental variables. These are presented in Table I. Considering that values of M vary over a million to one, values of σ/M are remarkably constant. The differences as a function of target size appear haphazard. The values of σ/M appear to decrease as B increases, although the effect is small. The values of σ/M appear to decrease as duration decreases, although the effect is still comparatively small. Before indicating the use to which these values will be put, let us consider the functional relations between values of M and the three basic experimental variables.

Values of M are plotted as a function of B for each of four sizes and for each of seven target durations in Fig. 2-8. In each case, values of M refer to the ordinate marked 50 per cent performance level. These are threshold contrasts, where as usual the threshold is defined by 50 per cent discrimination. All plotted points represent averages of the data from the two subjects. In most cases, the points are based upon one experimental session but in several cases, two experimental sessions were conducted under essentially the same conditions. The experimental data presented in Fig. 2-8 represent a total of 81,000 observations by the two subjects. The experiments required daily experimental sessions for more than 12 months.

We note that M decreases systematically as B increases and as duration is increased. These general results were expected on the basis of existing experimental data.[5] The exact nature of the relations could not, however, be predicted from existing data.

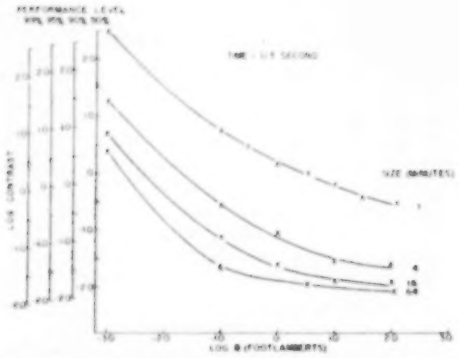

Figure 3. Data obtained with a time of exposure of 1/3 second. Each point represents at least 500 responses by two subjects.

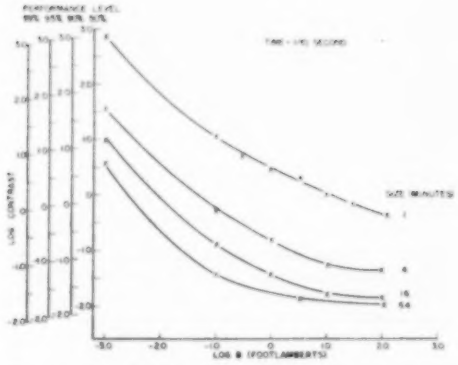

Figure 4. Data obtained with a time of exposure of 1/10 second. Each point represents at least 500 responses by two subjects.

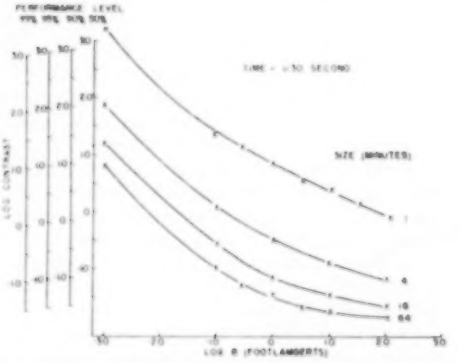

Figure 5. Data obtained with a time of exposure of 1/30 second. Each point represents at least 500 responses by two subjects.

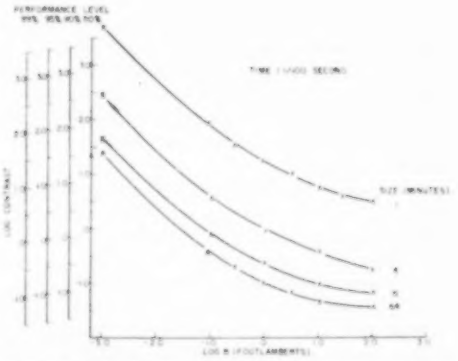

Figure 6. Data obtained with a time of exposure of 1/100 second. Each point represents at least 500 responses by two subjects.

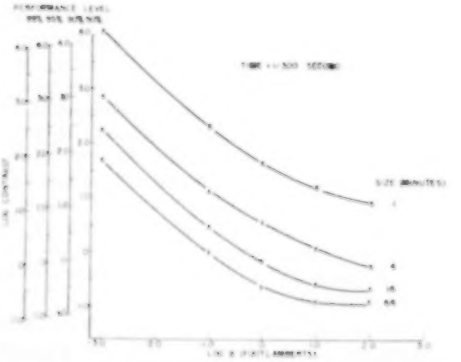

Figure 7. Data obtained with a time of exposure of 1/300 second. Each point represents at least 500 responses by two subjects.

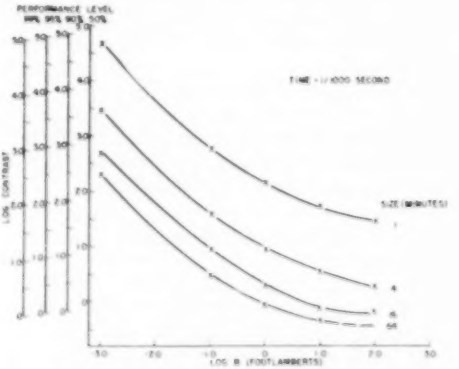

Figure 8. Data obtained with a time of exposure of 1/1000 second. Each point represents at least 500 responses by two subjects.

TABLE II.—Values of Z

Target Size (Minutes of arc)							
	1	4	16	64			
	1.87	1.97	1.92	1.90			
B (footlamberts)							
.001	.1	.3	1	3	10	30	100
1.98	1.98	1.91	1.90	1.90	1.88	1.87	1.83
Duration (seconds)							
1	1/3	1/10	1/30	1/100	1/300	1/1000	
2.13	2.05	1.87	1.86	1.84	1.84	1.77	

If we content ourselves for the moment with 50 per cent accuracy, we note that the experimental data permit us to evaluate the effects of target size and contrast and background illumination upon *speed* of performance, where *speed* is given by the inverse of target duration. We can discover the extent to which *speed* of performance increases with an increase in background brightness by noting the relation between B and target duration, given target size and contrast.

Let us now consider the most convenient manner in which to evaluate *accuracy* of discrimination. We have plotted values of M, corresponding to an accuracy of 50 per cent. We wish to know the correction to make in M to allow for a different level of accuracy than 50 per cent. Let us define Z, a conversion factor which will correct M to any desired level of accuracy as follows:

$$Z = 1 + f_a \cdot \sigma/M \qquad (3)$$

where f_a = factor to allow for accuracy level derived from standard tables of the normal frequency function.

We may tabulate values of f_a once for all as follows:

f_a	per cent accuracy
1.29	90
1.65	95
2.33	99

If we assume $\sigma/M = .390$ as in Fig. 1, values of Z are as follows:

Z	per cent accuracy
1.50	90
1.64	95
1.91	99

This means that, when $\sigma/M = .390$, a value of target contrast 1.50 times M, the threshold, will give 90 per cent accuracy; 1.64 times M will give 95 per cent accuracy; and 1.91 times M will give 99 per cent accuracy. These values may be verified by inspection of Fig. 1, where $M = 1$.

We may inquire to what extent values of Z vary for experiments conducted at different values of the three experimental variables. Values of Z for 99 per cent accuracy are tabulated in Table II, based upon values of σ/M presented in Table I and equation (3).

Values of Z vary among the four sizes by only ± 2.5 per cent; among the eight brightnesses by only ± 4 per cent; and among the seven durations by ± 10 per cent. Variations in Z for accuracy levels less than 99 per cent will vary less. It is concluded that variations in Z as a function of either size or background brightness are negligible. Variations in Z as a function of target duration are small, but should be allowed for in dealing with the present experimental data.

Insofar as Z is a constant multiplier times every value of M, we may represent different levels of *accuracy* by different scales of log target contrast, displaced by a constant amount representing log Z. In Fig. 2-8, the four ordinates have been computed by allowing for Z in this way. Each figure has been constructed with different values of Z, representing the fact that Z is not constant for different target durations. Within each figure, the same values of Z apply since we concluded that Z does not vary significantly as a function of either size or background brightness.

Use of the Data to Specify Quantity of Illumination

To utilize these data to specify the quantity of illumination, we have merely to specify the target size and contrast. We may then investigate the influence of quantity of illumination upon (a) *accuracy* and (b) *speed* of brightness discrimination. For example, let us assume the visual task involves brightness discrimination of a 1 minute circular bright spot whose brightness is twice that of its background. Contrast = 1.0; log contrast = 0. Values of B (footlamberts) for various target durations at each of four levels of *accuracy* are obtained as follows:

	Accuracy (per cent)			
Duration	50	90	95	99
1	1.0	2.5	3.6	4.8
1/3	2.8	8.3	10.	17.
1/10	10.	28.	33.	58.
1/30	69.	>100.	>100.	>100.

We can see from these values how *speed* and *accuracy* increase as B increases. Knowing the reflectance of the background material in question, we may compute the quantity of illumination required to provide desired levels of *accuracy* and *speed*.

Summary and Conclusions

A comprehensive study of brightness discrimination for uniform circular targets has been made. The accuracy of discrimination has been related to target contrast, target size, target duration, and brightness of background. If the target contrast and size are known, the *speed* and *accuracy* of brightness discrimination can be readily related to the quantity of illumination.

Acknowledgments

We are greatly indebted to Mr. D. W. McCready, Jr., and Mrs. Norma Lowry Tropp for their faithful and able assistance as subjects and research assistants. We continue to be deeply indebted to the Office of Naval Research, U. S. Navy, for the financial support which provided for development of the experimental apparatus utilized in the present study.

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DISCUSSION

DOMINA EBERLE SPENCER*: For several years, Dr. Blackwell has been telling the members of the Committee on Standards of Quality and Quantity for Interior Illumination about the extensive experimental work he has been carrying on. We have been awaiting the publication of his data with great interest. The paper "Brightness Discrimination Data for the Specification of Quantity of Illumination" represents the first tangible fruit of this work. Needless to say, this type of visual research is very important to the Illuminating Engineering Society.

However, before the results of Dr. Blackwell's experiments can provide a suitable experimental basis for recommendations of the Q and Q Committee, certain modifications and extensions of the work are needed:

(1) The results of this paper are based on observations by *only two observers* who visual acuity exceeded 20/20. No indications of discrepancies between the two observers are given. Yet the lack of coherence of the various sets of curves to the family patterns found in more extensive experimental investigations by other researchers leads one to question the significance of the curves drawn by Dr. Blackwell. Would these same peculiarities appear if a larger number of observers were used? How accurate are the data given? Could we not draw sets of curves of simpler shape which would represent the data with sufficient accuracy and yet be more significant than those drawn by Dr. Blackwell?

The illuminating engineer may also wonder if his rooms should be designed only so that two particular observers with above normal vision can see to perform tasks with a given accuracy. What about the typical occupant of the office or drafting room whose eyes are not above normal but are average or, as is more common, far below average? Will data for these two observers have any meaning in the practical case?

(2) If it is possible (and there is every indication that it is, according to numerous other experimental investigations) the results should be expressed *analytically*. If the data can be summarized by a single equation, meaningless irregularities will be smoothed out and the results will be placed in the most convenient form for application. Dr. Blackwell has taken, implicitly if not explicitly, a step in the right direction in his use of the S curves. But his inhomogeneous families of graphs are far from the most convenient form for the presentation of the results.

(3) We have here a large quantity of information on the detection of small round spots of low contrast. But not many of us are called upon to perform this type of visual task. Such work will become much more useful to the illuminating engineer when it is extended to tasks more closely related to those found in practical situations.

(4) Dr. Blackwell is to be commended for having obtained a reasonable approximation to a uniform surround. The fact that his curves have a continued downward trend at large quantities of light is indicative of the fact that the visual surround is adequately uniform.

An important extension of these researches would be to repeat them for non-uniform surrounds. We would like to be able to assess the effect of the moderately non-uniform surround encountered in the best contemporary lighting practice — say one which satisfies the 3:1 ratio. It would also be valuable to be able to determine the effect of glare sources such as are found, either in direct view or reflected from our work, in most artificially lighted luminous environments.

It is to be hoped that Dr. Blackwell can extend his research to cover some of these suggestions without causing the U. S. Treasury to run dry or bankrupting the I.E.S. Research Fund.

SYLVESTER K. GUTH*: Dr. Blackwell's comprehensive study of brightness discrimination considerably extends the scope of our knowledge of the relationships among the four fundamental factors of seeing. Not since the early work performed by Cobb and Moss has anyone undertaken such a thorough investigation. His study provides us with additional fundamental data for determining the speed and accuracy of performance for one type of simple visual task. As the author points out, when similar data are available for a variety of basic visual tasks, we will be able to apply visual performance data to actual work-world tasks. I hope that Dr. Blackwell and other investigators will extend such researches to include other tasks.

It may be desirable for Dr. Blackwell to amplify his very brief discussion of contrast. By expressing this factor always in terms of the background brightness, he obtains values of contrast in excess of 100 per cent (log contrast greater than 2.0). While his method is logical, convenient and useful, it may be confusing to those who usually express contrast in terms of the brighter of two adjacent surfaces and, thus are limited to a maximum of 100 per cent.

I believe that the extremely short exposure times of 1/300 and 1/1000 are of only academic interest in most lighting situations. However, it is well to extend experimental variables beyond the practical range to avoid inaccurate extrapolations. On the other hand, I wonder if at least one exposure time longer than one second would not be useful. Many tasks are such that time is of little importance, but the utmost in accuracy is required.

A word of caution may be in order for those who will want to apply these data immediately and directly. Dr. Blackwell's results establish general relationships for one specific type of visual task. Before they can be used on an absolute basis we will need data from more than two experienced observers and with more complex tasks. We need to know how various workers respond. That is, slow, average, superior, young, old, experienced, inexperienced workers and those with various degrees of visual abilities should be

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included as subjects. Our objective is to provide the proper seeing conditions for all the workers and not only for the best workers. Furthermore, considerable weight must be given to ease of seeing or the effort involved, and the degree of manual or mental dexterity required. In other words, lighting requirements are dependent upon many factors. Thus, this paper must be considered as but one more important step along the road toward complete knowledge of the effectiveness of light and lighting.

C. L. CROUCH*: I cannot pass up the opportunity of putting in a word in behalf of the I.E.S. Research Fund.

This paper represents the first step in the Fund's planned approach to establish a performance method of determining footcandles. It further represents the outcome of many hours of ardent discussion in the Standards of Quality and Quantity Committee where the vision researchers and the practicing engineers have wrestled with the problem of "how much illumination should be recommended."

You are acquainted with the Weston method of evaluating the illumination to obtain a given percentage of maximum performance based upon the output of work of cancelling Landolt rings having differing size and contrast. This method has received considerable study and respect from the S.Q.Q. Committee. But we have also come to realize its limitations — a question of validity of applying results from Landolt rings to other configurations in the work world, a question as to the scatter of Weston's experimental point to establish statistical significance and the question as to the significance of Weston's empirical accuracy factor. As a result it has been felt that this type of approach should be studied in this country and an attempt be made to separate out the pure functions of size, contrast, time for seeing, and accuracy. Having done this for a pure type of test object, "a circular disc," then studies can be made of the variations due to other types of configurations. Dr. Glenn Fry has proposed seven configurations as representing individually or in combination all those found in the field. Thus with the research continuing until all these configurations have been tested, you can see that there would become available a series of graphs similar to the results of this paper which would allow the practicing engineer to pick out the one applying to his configurations, size, contrast, time for seeing, and degree of accuracy desired, and find the illumination necessary. We realize that such a comprehensive program may require the "U. S. Treasury" but we hope that the I.E.S. Research Fund may do its share in making this worthy objective become a reality.

H. RICHARD BLACKWELL**: I very much appreciate the suggestions which have been made by Dr. Spencer, and by Mr. Guth and Mr. Crouch. I can agree with most of these suggestions without qualification. The experimental data we have collected represent only a beginning in the task of providing visual performance data upon which the specification of illumination levels should be based. We have studied only one visual capacity, brightness discrimination. Similar studies to ours should certainly be made of the other fundamental visual capacities. We are not entirely sure how many fundamental visual capacities there are. Studies of various visual capacities, which may seem to visual theorists to represent different fundamental capacities, will establish the extent to which these capacities are indeed fundamental and distinct from one another. At such time as all such studies have been completed, it will be possible for illumination levels to be specified on an entirely rational basis. The achievement of this goal is not to be expected soon, but we should keep working toward it with all possible dispatch. Even as far as brightness discrimination is concerned, our experiments are admittedly incomplete. The influence of non-uniform surrounds must be evaluated. As a matter of fact, we have requested funds from the I.E.S. Research Fund to carry out such a study. We should not content ourselves with data on two observers. I propose that we study brightness discrimination for several conditions of background luminance and target duration with a large number of observers. We do not expect the functional relations among these variables to vary greatly among observers. If this is true, then population data under a few experimental conditions, and complete data on a few observers, will suffice to give us good estimates of brightness discrimination as a function of background luminance for the general population.

I believe Mr. Guth is quite correct in remarking that exposure durations of 1/300 and 1/1000 second are of "only academic interest." However, I agree with Mr. Guth that it is desirable to study experimental variables beyond the limits of practical interest. As far as longer durations are concerned, we may utilize the data I published in 1946, representing durations as long as 16 seconds. If we compare the 1-second data with these earlier data, we find very little difference, suggesting that the 1-second data represent durations this long, or longer, with reasonable accuracy.

The one suggestion with which I cannot agree is that made by Dr. Spencer that we find a single analytic function and fit all the curves relating brightness discrimination and background luminance to it. I may remark that we are very eager to find *theoretical* arguments which will rationalize all our experimental data. It is apparent from examining the data, however, that no single analytic function adequately fits all the data. We cannot attribute this apparent perversity of the data to experimental errors. The factors which lead to the form of the brightness discrimination curves just do not happen to be so few that a single analytic function will describe all the experimental data. We hope to identify all the factors eventually and describe all the data with mathematical functions. As a matter of principle, I object to *force-fitting* all the data by a single analytic function. As a matter of practice, I believe that empirical curves which really fit the data are much preferable to a standard analytic function which does not really fit the data.

Finally, I must comment on the definition of contrast, first adopted in the 1946 report. Contrast was defined so as to simplify the comparison between the bright and dark targets investigated in the study which was reported. If we define contrast as $\Delta B/B$, where ΔB is either the brightness increment or decrement, the experimental data for bright and dark targets become virtually identical. Other definitions of contrast lead to large differences between the data for bright and dark targets, a situation which we believe to be artifactual. In the case of the bright targets, contrast may go to infinity. A value of ΔB twice that of B gives a contrast of unity. Such contrast is usually referred to as a 100 per cent contrast. In his discussion, Mr. Guth refers to 100 per cent contrast, and notes that the logarithm of this contrast equals 2.0. According to our definition, log contrast will in this case be zero.

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**Author.

Christmas in

In Southern California, where "snow for Christmas" is not the custom, a traditional Christmas atmosphere is produced almost entirely by the lighting. Holiday installations range from large-scale civic projects, to the decoration of private homes. The "snowless" California Christmas lighting on this and the facing page was compiled by Roy H. Kreyser of the Southern California Section of I.E.S.

A most spectacular demonstration of a civic installation covers over a mile of festively lighted Hollywood Blvd. in Hollywood. Gleaming Christmas trees and festoons of lights and tinsel adorn 90 trees, which are mounted on specially constructed steel street lighting standards. Each tree contains 176 25-watt colored lamps and a star with a 100-watt lamp. Illuminated bells and stars, swinging across the street, contain 1000-watt and 300-watt lamps respectively. At the grand opening parade, complete with floats and movie stars, 256 1000-watt floodlamps are added to produce the spectacle shown here.

Effective Christmas lighting of private homes can be either elaborate or simple. Below left, a snow-covered village surmounted by Santa Claus is highlighted by floodlamps located on the lawn. Decorated trees, in traditional manner, plus candelabra and a large "season's greeting" add to this Beverly Hills installation.

The private residence, below, uses a simple technique to present a holiday atmosphere. The decorated tree indoors is visible through the blinds; and a floodlamp outlines the light-colored exterior of this Westwood house.

California

This gaily lighted Christmas tree — flanked by palms — was erected in Pershing Square Park in Los Angeles. Decoration of the 11-ton tree includes 2500 25-watt colored lamps and a star at the top illuminated by a 1500-watt lamp. The Jones Decorating Company used a huge portable crane with the decorator suspended in a bos'n chair.

These giant deodars — cedar trees native to the Himalayas and planted in Altadena in 1885 — are hung, each winter, with colored lights to form a Christmas Tree Lane. Last year 8000 lamps were used. The trees vary in height from 80 to 100 feet with lower limbs extending 30 to 40 feet from the trunk. The Christmas lighting is a joint project of Altadena and Pasadena.

Bordering the entranceway to the Los Angeles Coliseum are beautiful deodars ranging from 25 to 30 feet tall. Every Christmas season 34 of these trees are decorated with brightly colored lamps and tinsel. A total of 3844 40-watt lamps are required. The star above the pylon, measuring 20 feet across, contains 215 50-watt blue lamps mounted on a wooden supporting frame. Although this photo does not show relative height, the blue star stands out against a dark sky at approximately 100 feet above the peristyle entrance.

Photographs and data courtesy of *Los Angeles Times* and Department of Water & Power, City of Los Angeles.

Approximate Direct Illumination At a Point From a Circular Fluorescent Luminaire

By WALTER A. HEDRICH

DEVELOPMENT and manufacture of fluorescent lamps has materially increased the number of applications of extended light sources. The tubes, available in a variety of sizes and colors, are predominantly straight. Within the past six or seven years the fluorescent lamp output includes tubes of circular design. Circline fixtures are manufactured for use in relatively small areas, and their present application is largely confined to offices and residences.

The general design problem involving the lumen method, wherein utilization factors are employed to obtain service footcandles on a work area, is not feasible when striving to attain some of the present lighting objectives in commercial and residential interiors. Ability to predict the approximate level and distribution of direct illumination from either straight or circline fluorescent sources of fairly uniform diffusion should facilitate the arrangement of such sources to obtain desired footcandles on restricted areas. The actual illumination at any point on the work area may, of course, be greater because of reflection from ceiling, walls and surrounding interior furnishings.

Object

A study was undertaken to show that the direct illumination from a circular fluorescent lamp in an annular type reflector, producing *approximately uniformly diffuse* annular brightness, approximates that produced by a theoretical uniformly bright one-sided plane annular source within engineering accuracy. Standard theoretical equations or graphs can then be used to approximate the illumination from such a circular fluorescent source.

Theoretical Relation

The illumination at any point P (see Fig. 1) on a plane parallel to a plane circular annulus of perfectly diffuse light, luminous on one side only, is derived as:

$$E_P = \frac{\pi B}{2}\left[\frac{r_2^2-(V^2+H^2)}{\sqrt{[r_2^2+(V^2+H^2)]^2-4V^2r_2^2}} - \frac{r_1^2-(V^2+H^2)}{\sqrt{[r_1^2+(V^2+H^2)]^2-4V^2r_1^2}}\right] \quad (1)$$

where $$B = \frac{{}_rI_o}{\pi(r_2^2-r_1^2)}$$

and ${}_rI_o$ is the maximum intensity of the uniformly

The complete report (from which this condensation was prepared) appears as Project RE-84, July 20, 1951, released by the Engineering Research Institute of the University of Michigan as a departmental project (Department of Electrical Engineering).

AUTHOR: Assistant Professor of Electrical Engineering, University of Michigan.

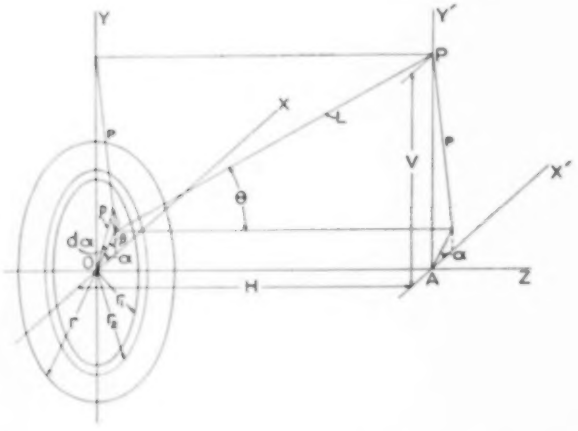

Figure 1. Physical arrangement considered in the development of Equation (1).

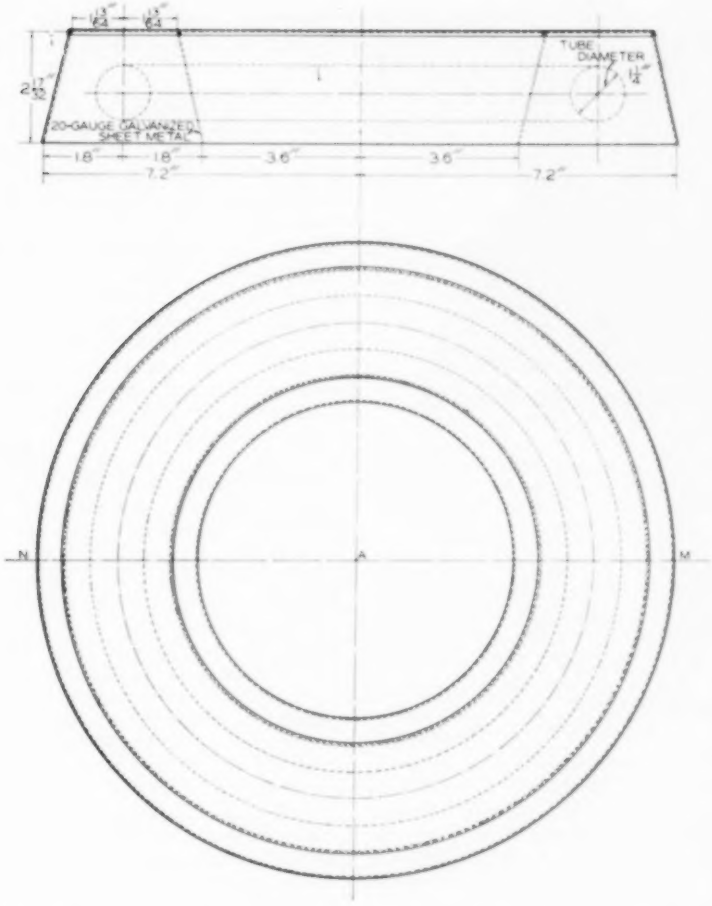

Figure 2. Diffuse reflector to accommodate 32-watt, 12-inch, T-10 circline fluorescent lamp.

diffuse ring source, r_1 and r_2 are the inside and outside radii of the source respectively, and H is the distance between the plane of the source and the receiving plane, while V is the radial distance of P from the normal axis OZ through the center of the annulus. Distances are expressed in feet; areas, in square feet; illumination, in footcandles; and brightness, in candles per square foot of projected area.

Diffuse Reflector

The layout shown in Fig. 2 is that of a diffuse reflector built of sheet metal to accommodate a 32-watt, 12-inch, T-10 circline fluorescent lamp. Selection of inner and outer radii is governed in part by currently available tube size as well as by the desire to expedite computation of the illumination from the theoretical plane annular source of uniform brightness. Neither restriction is essential to the general consideration of the problem. The inside surface of the reflector has a matte white finish. Operated over a period of the tube life when the rate of decrease of lumen output is minimum, the observed maximum-to-minimum brightness of the unit, measured across the luminous part of the tube and fixture diametrically opposite the non-emissive part of the tube, was 4 to 3. The average brightness for these observations as measured by a Luckiesh-

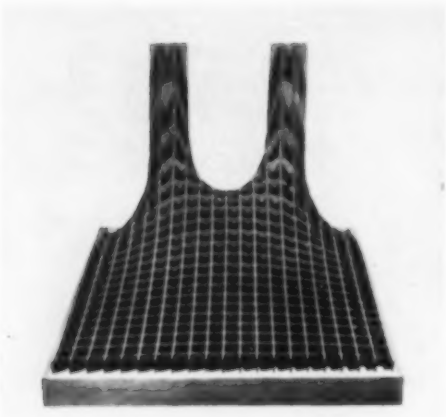

Figure 3. Front view of Masonite scale model of direct illumination from a plane circular annular light source of uniform brightness. Source dimensions: r_1 = 0.3 ft.; r_2 = 0.6 ft.

Taylor brightness meter was 1580 footlamberts. The actual maximum-to-minimum brightness ratio for the unit as a whole must, therefore, be greater than 4 to 3 due to the non-emissive 4-pin base whose mean length is about 3.5 per cent of the mean length of the circline tube.

Scale Model

Fig. 3 shows a three-dimensional scale model constructed to represent the theoretical illumination (Equation 1) on a work plane parallel to a plane circular annulus of uniform brightness. The radial dimensions of the theoretical source are identically those of the projected area of the diffuse reflector.

Illumination from the scale model at any point on a plane parallel to the source may be computed from:

$$E_P = K'_r I_o = 0.2\,(z-2)_r I_o \qquad (2)$$

where z represents the number of inches of vertical ordinate measured from the inside base of supporting frame along the line of intersection of finished surfaces of masonite. The constant K' is evaluated from Equation (1) with B expressed in terms of $_rI_o$.

It is to be noted that the distribution exhibited by the model is that for a region relatively close to the source, suggesting a circline unit for desk lamp application. Restrictions based on applications defining a specific region of interest or governing the relation between outer and inner radii do not incur a loss of generality as far as the object of study is concerned.

Tabulated Data

Table I contrasts footcandle values (corrected for meter calibration) as obtained by measurement under the unit shown in Fig. 2 with similar values computed from Equation (1). Orientation No. 1 marks a tube position within the reflector for symmetry about point A in Fig. 2. The computed footcandles are based on the average brightness of the luminous portion of the reflector diametrically opposite the non-emissive part of the circline lamp. Like footcandle measurements were made for an asymmetric tube Orientation No. 2 which places the center of the non-emissive portion of the circline tube at 90 degrees with respect to its position in Orientation No. 1. Data for tube Orientation No. 2 do not appear in Table I, but reveal the maximum difference obtainable for points on the work plane equidistant from, and on opposite sides of, point A along line MN.

TABLE I.—Footcandle Readings, Computed Footcandles

Orientation No. 1

H†		$V = 0$†	$\sigma_{y/x}$	$V = 0.1$	$\sigma_{y/x}$	$V = 0.2$	$\sigma_{y/x}$	$V = 0.3$	$\sigma_{y/x}$	$V = 0.4$	$\sigma_{y/x}$
1.2	m_o*	191.6	.0202	189.7	.0202	185.5	.0202	178.6	.0202	169.4	.0202
	m_i**	223.0		221.4		216.4		208.4		197.6	
1.4		153.4	.0205	152.3	.0205	149.7	.0205	144.7	.0205	138.7	.0206
		175.8		174.6		171.3		165.8		158.5	
1.6		123.9	.0207	123.5	.0208	120.8	.0207	118.1	.0208	113.7	.0208
		141.1		140.3		138.1		134.3		129.3	
1.8		102.1	.0211	101.7	.0211	100.6	.0212	98.47	.0213	95.33	.0213
		115.3		114.7		113.1		110.50		107.0	
2.0		84.76	.0213	84.19	.0212	83.71	.0213	82.38	.0215	80.57	.0217
		95.70		95.30		94.20		92.30		89.80	

*m_o represents actual footcandles (corrected meter value). **m_i represents computed footcandle value. †H and V expressed in feet.

Evaluation of Test Results

The question as to how well the point-by-point direct illumination, computed from Equation (1) under the conditions herein specified, agrees with that produced by the actual luminaire is answered in a statistical treatment of data appearing in the original paper. The standard deviation evaluated from the test results in Table I for the symmetric case appears as $\sigma_{y/x}$, wherein y refers to measured illumination and x to measured source brightness. The maximum value attained by the standard deviation for the region under consideration is 0.0228. Thus the maximum difference between the computed value of illumination and the corrected meter value for this region could not be greater than $3\sigma_{y/x}$ or 0.0684. For the asymmetric case, the standard deviation attains a maximum value of 0.0232, and the corresponding difference between computed value of illumination and the corrected meter value for the same region would not exceed 0.0696.

Conclusion

The immediate problem is not that of the specific luminaire under investigation, nor are the results necessarily restricted to any particular region surrounding the source. Treatment of the specific case herein merely serves to indicate the type of result to be expected. The paper shows statistically that the measured values of illumination cannot differ from the values calculated for a perfectly diffuse source of like dimensions by more than 6 to 7 per cent. This marks essentially the maximum difference that could be expected in any case. The probability is that the actual difference encountered over a fairly representative number of points in any region of practical significance will be less than 5 per cent. Therefore it is concluded that for any practical annular light source (with a maximum-to-minimum brightness not exceeding 4 to 3) the formulas for perfectly diffusing annular sources may be used. In this connection, the average brightness of the actual source, obtained from measurements along any radial line over the luminous part of the reflector remotest from the non-emissive portion of the tube is employed in computing the footcandle values.

If, for instance, circular coves and coffers are provided with continuous cold-cathode or slimline tubes to create an approximate uniformly bright ceiling element, the non-luminous tube element is negligible in comparison with the total length of tube. Such sources are practically axially symmetric, and, if the ceiling and built-in structural elements are highly diffusing and conform to a maximum-to-minimum brightness ratio of 4 to 3, calculations based on Equation (1) or its equivalent should be sufficiently accurate to warrant their use for extended light sources of this type, especially in view of the probable accuracy of results obtainable.

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and Standard Error for Circline Fluorescent Luminaire.

A ⟷ M Symmetric

$V = 0.5$	$\sigma_{y/x}$	$V = 0.6$	$\sigma_{y/x}$	$V = 0.7$	$\sigma_{y/x}$	$V = 0.8$	$\sigma_{y/x}$	$V = 0.9$	$\sigma_{y/x}$	$V = 1.0$	$\sigma_{y/x}$
158.8	.0202	147.7	.0205	135.1	.0208	122.3	.0211	109.4	.0215	96.61	.0218
184.4		169.4		153.4		137.1		121.1		105.8	
131.1	.0207	123.3	.0210	114.1	.0210	105.7	.0215	96.19	.0217	87.71	.0222
149.6		139.4		128.5		117.1		105.7		94.6	
109.1	.0211	103.4	.0212	97.62	.0215	90.95	.0217	84.19	.0220	77.52	.0223
123.1		116.1		108.4		100.4		92.10		84.00	
91.71	.0214	88.0	.0217	83.42	.0216	78.28	.0218	73.62	.0222	68.19	.0224
102.7		97.7		92.20		86.90		80.40		74.30	
77.47	.0216	74.47	.0218	71.62	.0222	67.90	.0222	64.47	.0225	60.76	.0228
86.70		83.10		78.70		74.80		70.70		65.70	

Developments in Submarine and Small Vessel Lighting

By DEAN FARNSWORTH

THERE are today over 35,000 vessels in the Navy, Marine, Army and Coast Guard Services. Small vessels of 300 to 2,000 tons displacement account for the vast majority of these, to which we will add submarines, much larger, but with individual compartments which present similar design problems. In spite of their special lighting requirements such vessels received little attention until recent years. Lieutenant (now Captain) Robert T. Alexander published an excellent analysis of illumination requirements of small vessels in 1941.[1,2] However, no appreciable change occurred in their lighting installations.

It became increasingly apparent during the war years that the application of standard lighting methods to small vessels was producing unsatisfactory results. Naval and Marine lighting standards were lower than industrial practice; the actual installations were in fact even poorer. Ocular complaints increased and were frequently ascribed by the personnel to bad lighting conditions. Tests conducted in 1944-45 at the Medical Research Laboratory indicated that the visual acuity of submariners returning from several years' sea duty was lower than that of recruits to an extent which would not be accounted for by age differences. Personnel made comment to the effect that a third-rate factory would not tolerate the wretched lighting with which their boats were supplied.

Three new developments made the situation critical: first, the masses of new, specialized equipment which were crammed into all compartments—this made proper light distribution very difficult; second, the increased use of such instruments as radar, sonar and computing machines—this demanded close, continuous and fatiguing use of the eyes by most of the crew; and third, the advent of the snorkel (and now the atomic-powered submarine) — this permitted continuous living underseas, perhaps for months, without the rest provided by daylight, fresh air and liberty ashore.

The problems were not to be solved simply nor without the cooperation of more men and agencies than could be named in the space of a page. After a few years it became evident that the lighting of submarines and small naval vessels could not be modeled upon industrial, office, aeroplane or passenger vessel traditions but that it should be considered as an entirely new field to which original approaches would have to be made.

In order to appreciate some of the problems in lighting a submarine interior we should attempt a visualization of what the inside of a submarine looks like. It consists of a series of pressure tight cylinders fastened end to end. Imagine the inside of a boiler — a large boiler — congested with pipes, instruments, valves, meter panels, electronic gear, control handles, and cabinets of all sizes, under and between which are narrow passageways for the operators. There are bunks between the torpedoes, electronic gear between the bunks and controls which are operable from the mess tables.

The original approach to lighting this conglomeration of equipment was by way of the customary three or four centrally located and routinely spaced fixtures with wide angle reflectors. However, small spaces thickly filled with a variety of equipment are not responsive to the same rules of lighting practice as would be found elsewhere. The results were, first, unequal distribution of light due to the irregularity of the equipment layout. Second, there were high glare sources of all types — the low lamps were in the line of sight of the eye, there were high brightness areas because the lamps were necessarily placed so close to the equipment and overhead, and there was reflected glare from the many highly polished surfaces. Third, many of the working areas were so dark as to be hazardous, to make dials illegible and, in places, literally to require the use of flashlights.

With the advent of larger and more complicated items of electronic gear, the lighting situation became intolerable. The number of incandescent light sources could not be increased without taxing the generator capacity, their size made it difficult to find spaces to locate them, and the design of available fixtures was such that increase in the number of units actually increased the number of glare sources.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, Sept. 8-13, 1952, Chicago, Ill.
AUTHOR: Lieutenant Commander, Medical Research Laboratory, U. S. Naval Submarine Base, New London, Conn.
The opinions or conclusions expressed in this paper are those of the author. They are not to be construed as necessarily reflecting the views or endorsement of the Navy Department.

All analyses showed that, in addition to such usual considerations as appearance, ease of cleaning and lamp replacement, waterproofness, resistance to salt, oil and chemical vapors, the following requirements were of special importance:

(1) The units should be small, and of a shape that would fit between pipes and and in narrow channels.

(2) The light distribution should be efficient and directional, primarily in an angular plane.

(3) Both the luminaires and the lamps should be highly shock resistant in order to sustain depth charging of extraordinary intensity.

(4) A variety of specialized luminaires would be needed but the logistics of supply aboard submarines required that they should utilize as few types of lamps as possible.

(5) They should be extremely efficient in current consumption in order not to put an unreasonable load upon the power supply.

(6) The lamps should be long-lived and vibration-proof.

(7) In case of breakage the glass should not litter the compartment.

(8) The equipment should be simply adaptable to a complete dark-adaptation (red lighting) system.

(9) Heat radiation should be minimal.

The initiative and ingenuity of certain manufacturers created the first actual luminaires for testing. Experimental installations were made of several types of fluorescent, incandescent and low wattage systems before the emergence of the present solutions. While progress will not stop with these, it can be claimed that they now make possible the illumination of small vessels at levels which are comparable to recommended industrial practice. Illumination of working areas within modern submarines of the Killer and high-speed Attack classes measures between 10 and 30 footcandles, with localized lighting up to 40 footcandles. It is of even more significance that brightness contrasts have been generally reduced to ratios of the order of 1 to 40.

Eight-watt, 12-inch fluorescent lamps were the core of many of the successful solutions. These have proved superior in shock resistance to even rough service incandescent lamps. They permit the design of units which can be "tucked in" between pipes, have low current consumption and permit efficient fixture design with well controlled distribution. Some of the forty-two special luminaires incorporating fluorescent lamps designed by the L. C. Doane Company for specialized shipboard applications are shown in Fig. 1.

The most difficult problem was that of uniformly lighting high banks of dials from sources placed overhead and very close to the panel. This has been solved to the extent that ratios of better than 1 to 5 are now obtainable even under extreme conditions. A comparison is shown in Fig. 2 of a small group of dials illuminated by a 60-watt incandescent light in an old standard reflector with

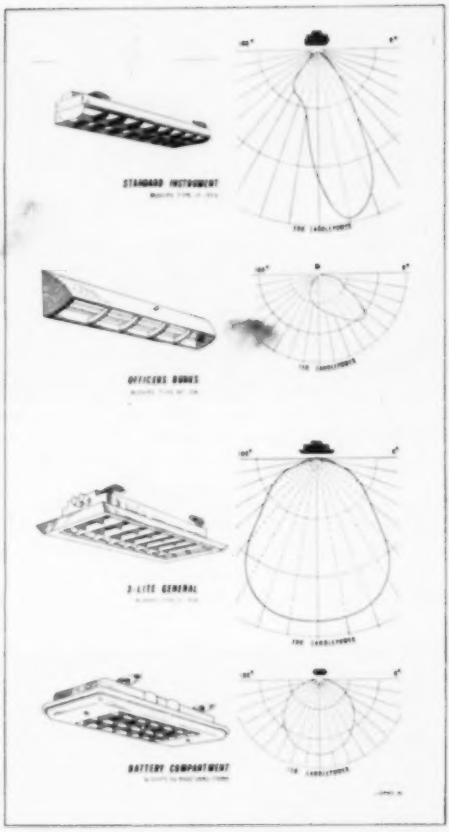

Figure 1. Some of the forty-two special luminaires, incorporating fluorescent lamps, designed for specialized shipboard applications.

that provided by two 8-watt fluorescents in the new directional fixture. To correct for the length of throw and the angle of incidence on the lower dials it is necessary that some 30 times as much light be directed through the 10-degree plane (from the normal) as through the 60-degree plane. For the first time it is possible to provide reasonably uniform illumination over high banks of dials (Fig. 3) and to be able to find spaces for enough such units.

However, general compartment, instrument and dial illumination is but one part of the picture; "four hours on watch and four off" means that a man has hours for recreation, light reading, and naval correspondence courses. Recreational use is made of the mess compartment (now frequently referred to as the "dinette") where special localized lighting is placed under the condiment racks in shallow reflectors of less than an inch and a half in

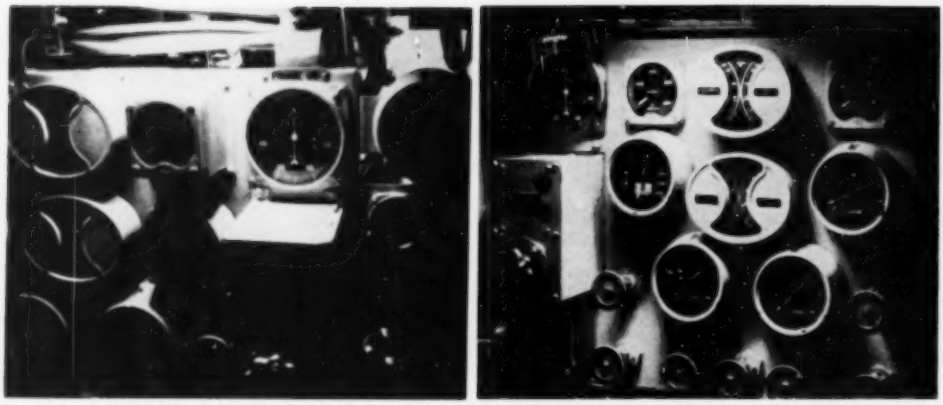

Figure 2. On the left is one of the Engine Room control panels showing the best distribution obtainable by a 60-watt incandescent lamp in an open reflector. On the right is a similar control panel relighted with two 8-watt fluorescents in a Doane overhead directional luminaire.

total depth. Standard white fluorescent lamps not only eliminate the shadow underneath the racks but make the food more attractive and provide a special illumination level for reading and card playing.

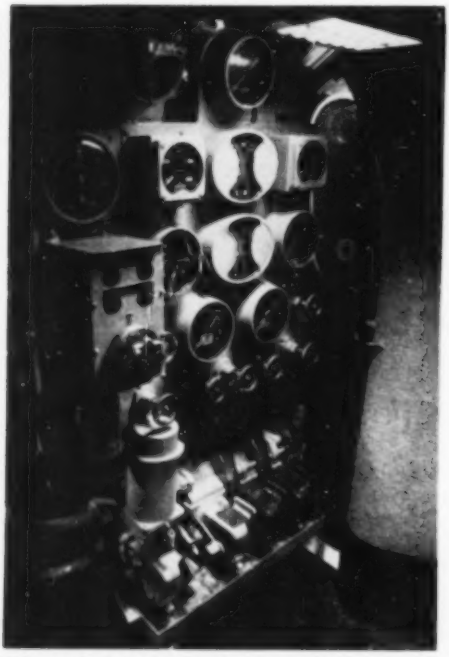

Figure 3. Vertical distribution over a 6½ foot operating panel where the luminaire must be placed within 8 inches of the panel.

Outside of the messing areas there are no special recreational rooms and a man has no castle for a home but his bunk. There he reads, talks, plays cards, and writes letters home. An individual bunk light has been the dream of every man in the service. The present unit is partially successful: an incandescent light with a protecting cover which raises to form the reflector is mounted on an arm which folds beneath the mattress when the bunk must be secured (Fig. 4).

Other specialized units are required for such locations as the battery compartments where there is headroom of only two or three feet, the officers' wardroom where most of the official business of the boat is conducted, officers' desks and bunks, the narrow passageways, the yeoman's desk and radioman's shack, shaving mirrors, the galley and crew's mess.

Red Lighting for Dark Adaptation

A most critical phase of lighting aboard military vessels is one which is almost exclusive to them — that which concerns the need for dark adaptation. Attack and defense most often occur at night, late twilight and before dawn. At such times it is possible to see only by the use of the scotopic, or rod, mechanism of the eye. It has been found that red lighting will permit rapid subsequent dark adaptation if it meets certain specifications of quality and intensity, and that men can continue their regular duties under such lighting. In consequence there are areas aboard all military vessels in which planning must be made for total red illumination in the evening and during the night. The specification for spectral quality permits transmission of less than .001 of the visible energy at wavelengths below 600 mu.

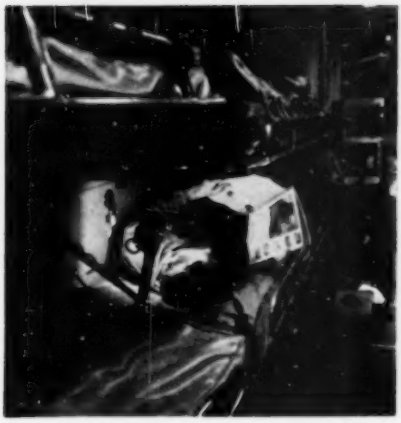

Figure 4. Men's bunk light in use for reading. When not in use, units are folded beneath the mattresses.

In addition, these red light levels must be low in order to provide for rapid subsequent dark adaptation. Some of the red lighting levels recommended by the Visual Engineering Section of the Laboratory are given in Table I.

These might appear to be extremely low levels to those who are only familiar with curves derived from threshold data such as Lythgoe's. A threshold is a 50-50 point — 50 per cent of the time seen, 50 per cent not seen, or, 50 per cent right, 50 per cent wrong. Such data are not directly useful in daily occupations where we cannot afford to be right only 50 per cent of the time. It wouldn't be good for business. It is impossible in shipboard operations. Nor are daily tasks on the threshold level. Most of the things we are required to see are easy to see — that is, *supra-threshold*. Therefore a different psychophysical technique is required for determining the minimum lighting levels at which ordinary visual tasks can be accomplished with reasonable accuracy. One method consists in recording the per cent error scores made on a variety of supra-threshold tasks and adjusting the curves to coincide at the plateau of good performance recorded at the higher levels of illumination used in each experiment.

TABLE I.—Red Lighting Levels for Dark Adaptation.

CONTROL ROOM	
Illumination on working areas	.01 - 0.4 ft-c
Illumination on black-and-white dials, figures, nameplates	.03 - .10 ft-c
Brightness of instrument faces (white portion)	.02 - .08 ft-L
Brightness of indicator lights (not to exceed 1 sq. in. area)	.10 -1.00 ft-L
CREW'S MESS AND OFFICERS' WARDROOM (These are readiness areas)	
Illumination at table top height	0.5 -2.0 ft-c
Brightness of any area in the visual field: not to exceed	2.0 ft-c

Seven such curves, from four investigators, are shown in Fig. 5. The tasks were various: perception of depth, identification of letters, addition and dial reading from small and large dials. Because of the variety of tasks, of stimuli, of methodology, of criteria and of scoring large differences are to be expected. However, in all studies a kind of breakpoint occurs in the log unit between 0.01 and 0.1 footlambert. Analysis of a number of such studies of supra-threshold tasks justified the specifications suggested in Table I.

It is not contended that such low brightnesses are most desirable but there is no doubt that they are sufficient for ordinary occupations involving clearly supra-threshold tasks.

The present method of achieving the specifications for spectral quality and intensity is by enclosing the fluorescent lamp in a red acrylic tube. Internal red lighting of instruments presents problems which have not yet been solved.

Coordination of Lighting With Compartment Design

At no time was it assumed that the redesign of the fixtures would be sufficient to establish a good visual environment. As we know, the design, color and reflectivity of the surroundings greatly affect the appearance of light in a room. The finding that standard lighting methods required drastic modification for small compartments was minor compared with the reversals of decorating principles which sometimes proved necessary.

Several specific effects were attempted in the coordination of lighting and compartment design.

1. Sense of space. The first plan was to paint practically everything in each compartment in one color in order to "pull together" the diversity of shapes, colors and textures of the equipment. This succeeded, but it succeeded better when one substantial contrasting color area was emphasized in each compartment so that the uniformly-colored but heterogeneous shapes could "fall away" from the accent area.

2. Change of pace. Working areas are specified in one color, living areas in another. This seems to be all that is necessary to provide variety and a sense of orientation. It was first thought that warm tones should be used in the living areas and cool tones in the working quarters. This formula has been deliberately reversed on some boats with equally acceptable results.

Another standard principle of decorating proved untrue when applied to small compartments with varied lighting. It has been generally accepted that

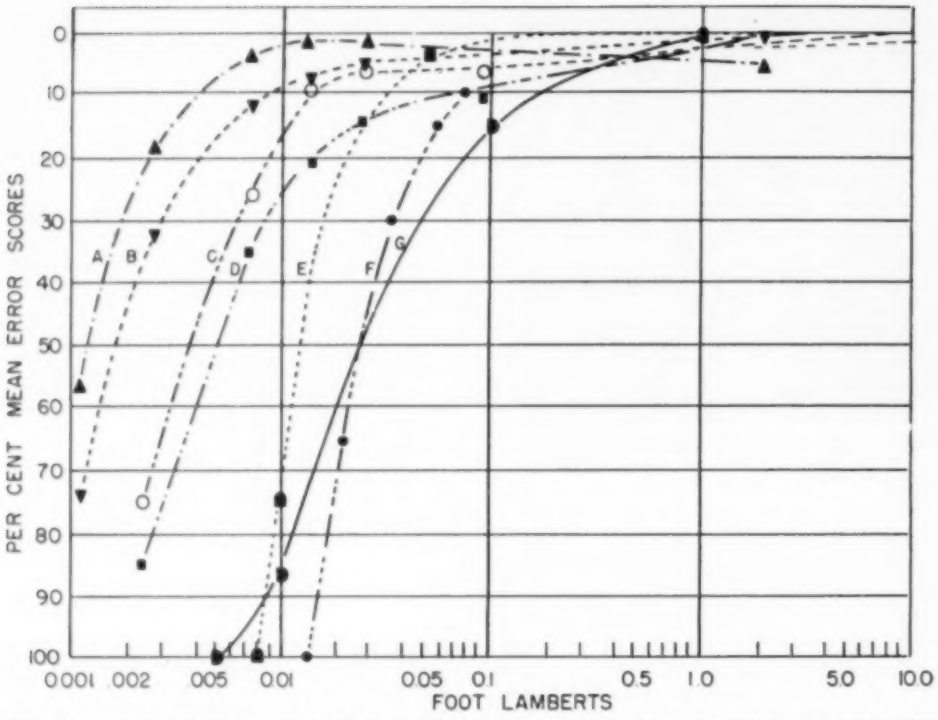

Figure 5. Visual performance at low brightness levels. Per cent mean error scores adjusted to best performance.

A. Large dials — gross criteria
B. Large dials — fine criteria
C. Small dials — gross criteria
D. Small dials — fine criteria

Chalmers, Goldstein and Kappauf, "The effect of illumination on dial reading," Wright-Patterson Air Force Base, Dayton, 1950.

E. Addition Problems — 20-pt. type. Rock, Milton L., "Visual performance as a function of low photopic brightness levels," Wright-Patterson Air Force Base, Dayton, 1950.

F. Legibility of letters — 20/40 size. Brown, Fred E. "A Study of the legibility of transilluminated markings in aircraft cockpits," Aeronautical Medical Equipment Laboratory, Philadelphia, 1949.

G. Depth perception — Rock, M. L., *op. cit.*

a sample color will appear more intense when applied to a whole room, and that color differences will be emphasized when applied to separate rooms. To the contrary, it was found that color differences were almost eliminated when applied to small compartments. It was therefore necessary to increase the chromatic contrasts of the colors in the scheme far beyond what would be normally acceptable.

3. Low background brightness. Paint reflectances are deliberately low. Backgrounds which are the same or of lower brightness than the object attended to are known to increase acuity and ease of seeing. Men in submarines look at instruments and each other. When a man looks another in the face, it should—for morale's sake—appear clear, healthy and lively. Therefore all background colors are chosen primarily to enhance and lighten skin color. Reflectances of the standard colors range between 30 per cent and 50 per cent.

4. Spectral coordination of light and colorant. The original paint scheme on the *SS Permit* was designed for incandescent light — under which it was highly successful. The yellow-gray standard, however, turned to a dirty mustard on the next boat which had cool white fluorescent. This was remedied by the addition of light red to the formula, just in time to meet an installation of warm whites which produced a soft pink effect in the crew's quarters. The moral to this adventure was not the well-known fact that colors change with their illuminant but that the *spectral distribution* of paints must be specified in conjunction with the spectral emission of the sources.

5. Uniform instrument lighting. The best de-

signed luminaires cannot make light turn corners in mid-air, nor change its habit of reflecting at the angle of incidence. When instrument panels are designed so that the top dials are tilted forward and the lower dials tilted up, (1) more uniform distribution is obtained, (2) lamp reflection from the dial faces is eliminated, (3) the shadow of the dial rims is reduced, and (4) the direct view increases reading accuracy and reduces parallax.

6. Elimination of glare. Because of the narrow passageways, most surfaces are seen at oblique angles, which increases the intensity of reflected glare from the well-polished bright work which has long been the pride of the Navy. Louvered luminaires were the first step in glare elimination, but substitution of modern materials for polished brass and stainless steel has reduced reflected glare to a minimum. Paint gloss is limited to 30 units, and now covers all metals except hand controls. Satin-finished plastic laminates of low reflectance substitute for the CRS rub boards which formerly lined the passageways and compartments.

One of the chief sources of direct glare was formerly from the white overheads near the lamps. Attempts to use indirect lighting only increased the glare because the overhead was so low. Both white paint and indirect units have been eliminated.

7. Eye-rest areas. It is believed by this laboratory that the pupils of the eye are naturally used to change of illumination and the opportunity to exercise, particularly to rest by dilation. Therefor each compartment should be provided with a low brightness area where this natural ocular rest is possible. One application is to panel the compartment at head height with dark, natural wood laminates; another is to paint one wall in a solid, dark color.

This is a tale of coordination of better lighting luminaire design with many other fields of human engineering. Lighting units alone could not have produced better vision, but without much better lighting luminaires we could not have achieved better visual conditions. Our common goal is to do all that illumination can do for the habitability environment of the Navy personnel of today.

References

1. Alexander, Robert T., Lieut., USCG: "Illumination of Coast Guard Vessels," *J. Am. Soc. Naval Engr.*, Vol. 53, No. 1 (February 1941).
2. ————: "Light Sources for Coast Guard Use," *J. Am. Soc. Naval Engr.*, Vol. 53, No. 2 (May 1941).

DISCUSSION

CARL E. EGELER*: Commander Farnsworth is to be commended for his broad approach to the subject of submarine lighting, a feature of submarine design which has not kept pace with the many mechanical and marine design developments which are characteristic of today's underwater craft. With available space so limited, past practice too largely has been the arbitrary spotting of lighting units originally designed for other services, with little engineering of the lighting and virtually no consideration of the comfort of the personnel, either from the standpoint of glare, or the brightness and color of the environment which can affect the crew physiologically so favorably, or otherwise. As Commander Farnsworth points out, the submarine of today may in time of war or national emergency require the crew to live for weeks or even months with no change in their cramped working and living surroundings.

At last there is effective lighting for the meters and instruments cleverly engineered to the seeing tasks, with the use of small fluorescent lamps in combination with paraboloidal reflectors. And for the other working and off-duty recreational seeing tasks and reading, lighting units which take advantage of the low brightness of the fluorescent lamps, and relaxing or stimulating colors, reduce the feeling of confinement previously felt to be a necessary accompaniment to the cramped quarters.

The lighting of other Navy ships as well has not kept pace with the great advance in fire control and ordnance, navigational aids, and marine engineering. Unfortunately, this applies to ships placed in commission since World War II but the Navy realized several years ago the possibilities of improving crew morale and providing better working conditions by improving the quality as well as the quantity of lighting. With the cooperation of an Industry Lighting Committee specifications were developed for new lighting units to emit light upward, have low brightnesses in the usual lines of sight, and take advantage of the higher efficiencies of fluorescent lamps. A program is underway for converting the lighting systems of the many ships of the fleet, to utilize the up-to-date units.

It is noted that all of the gauges and instruments shown on figures 2 and 3 have black dials with white numerals. If white dials were used with black numerals, better balances in the brightness pattern would result and equal or better visibility of the scales and needles would be obtained. Is the use of white scales part of the Navy's future program?

R. W. MCKINLEY*: As a former employee of the Electrical Section of the Bureau of Ships with responsibility related to the development of shipboard lighting equipment, I was much pleased to learn through Commander Farnsworth's paper of the progress that has been made in the fluorescent lighting field.

In his discussion of red lighting for dark adaptation, I believe that he is probably aware of the importance of the brightness of the light source itself but perhaps he did not feel it was necessary to mention it as a separate problem.

It happens that I was responsible for the initial survey of darkened-ship conditions on naval vessels which led to the Navy-wide adoption of a long-wavelength red illumination system. In that study which was conducted both in the laboratory under controlled conditions and on naval vessels of many types, it was found that the brightness of the light source itself when exposed in the field of view was the critical factor in determining dark adaptation recovery time.

*Illuminating Engineer, General Electric Company, Nela Park, Cleveland, Ohio.

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For this reason, a water tight metal housing with a red filter lens was devised to replace the common "steam tight globes" which in many vessels provided most of the general illumination. By extending the metal cylinder beyond the filter lens, brightness in the field of view was reduced to levels comparable to those shown in Table I and dark adaptation recovery time was considerably speeded.

While I agree fully with Commander Farnsworth that the very low red illumination levels make it practical to perform critical visual tasks accurately, I think that it should be mentioned also that this visual performance is achieved at considerable expense in visual comfort.

DEAN FARNSWORTH*: Our Visual Engineering Section recommends black numerals on white dials in compartments which are normally illuminated by white light. We recommend white numerals on black backgrounds in compartments which must be red lighted for dark adaptation. Acuity is the same for black on white or for white on black. However, since dark adaptation is a summation function of the brightnesses in the visual field, black dials under a given illumination permit more rapid subsequent adaptation over white dials since the total light flux received at the eye is much less. For example, if the white markings occupy only 1/20th of the area of a black dial the effect on subsequent night vision is only 1/20th of that of a white dial, yet the "seeability" is the same.

Where red lighting for adaptation is not required there is a slight preference for a white dial because reflections from the glass cover (which is normally present) appear to be less disturbing to the readability of a white dial.

*Author.

Relighting and Remodeling a Jewelry Store

Originally this jewelry store, in Chico, Calif., had "modern fluorescent" lighting — bare 40-watt units suspended four feet from a 17-foot ceiling. Walls were dark, show cases were lined with black cloth, wiring was obsolete. In remodeling the interior, a false ceiling of light acoustical block was installed 10 feet from the floor. Walls were repainted with flat light gray, and show cases relined with light gray material. Nine 4-lamp luminaires equipped with diffusing glass, 96-inch slimline lamps and using 200 ma high power factor ballasts, are suspended 12 inches from the ceiling. In addition 16 PAR-38 150-watt projector flood lamps provide high intensity localized lighting on the show cases. These are mounted directly over the front edge of the showcases to minimize reflections from the glass tops. Average general illumination is 77 footcandles; 135 footcandles on the counter top with both sources. Switching arrangement of the fluorescent luminaires is staggered from row to row, while the projector floods are foot-controlled in groups of four by switches located on the floor behind the counter.

This installation won an I.L.E. Merit Award for Hugh J. Richardson, Pacific Gas & Electric Co., Chico, Calif.

Recommended Practice for Supplementary Lighting

Prepared by Subcommittee on Supplementary Lighting of Committee on Lighting Study Projects in Industry of the Illuminating Engineering Society*

FOREWORD

In 1943 a subcommittee of the I.E.S. Lighting in the Work World Committee (predecessor of Lighting Study Projects in Industry) was formed to prepare illumination performance recommendations for supplementary lighting. This subcommittee began its work by studying the fundamentals of close-up lighting in manufacturing processes.

During the 1946-47 year a report was drafted which covered the visual requirements for supplementary lighting and classified supplementary lighting equipment according to size of source, brightness and beam spread. The committee name was changed to Subcommittee on Supplementary Lighting in 1948 and a preliminary outline for the present report was drawn up soon thereafter. The first two drafts were written in 1950, and used by the Committee in preparing supplementary lighting sections for the Second Edition of the *IES Lighting Handbook* and the 1952 revision of the "American Standard Practice for Industrial Lighting." This final committee-approved draft represents the third revision of the 1950 manuscript.

SUBCOMMITTEE ON SUPPLEMENTARY LIGHTING

W. H. Kahler, *Chairman*

G. F. Dean — E. A. Linsday
L. E. Goble — R. E. Mausk

1. Introduction

1.1 — *Purpose* — This report is prepared to serve as a guide in the solution of lighting problems requiring specific illumination that can be provided by supplementary lighting equipment.

1.2 — *Definition of Supplementary Lighting* — Supplementary lighting is used to provide a specific quantity and/or quality of illumination which is required for the particular task. As the name implies, it is usually employed in addition to the general lighting system.

1.3 — *Scope* — The Recommended Practice covers a fundamental analysis of seeing tasks and explains the means of visual perception involved in distinguishing detail. The perception of everyday objects is generally taken for granted and is accepted without an understanding of how and why the objects are seen. By analyzing the means of perception it is easier to devise ways of emphasizing certain details for the purpose of inspection, display, or improvement of visibility for easier seeing. The report includes a classification of supplementary luminaires on the basis of photometric characteristics. Perception and lighting equipment are combined in many examples to show solutions to typical supplementary lighting problems.

2. Analysis of the Seeing Task

2.1 — *Visual Perception* — **(a)** Before the proper quality and quantity of illumination can be specified for a certain seeing task, it is necessary to recognize the seeing task and to understand its light reflecting and/or transmitting characteristics. The seeing task usually involves certain detail either small or large that must be visually resolved in the midst of a more or less complex visual field. It is therefore found that a study of the visual task necessitates a knowledge of:

(1) the actual object of regard,
(2) its immediate background,
(3) the general surroundings.

The task itself consists of the object of regard and the immediate background. For example, in reading this page on a desk the objects of regard are the printed characters, the background is the page itself, and the surroundings are the desk top and remainder of the room. The printed page would be considered as the visual task. In the case of a machinist's micrometer the lined divisions are the objects of regard, the polished barrel is the background and the surroundings are usually a machine, work bench, or part of the room. In a show-window display of a small appliance, the appliance as a whole is the object of regard, the background would be the material against which the appliance was seen and the surroundings would be considered as the entire show window.

(b) In the analysis of the seeing task it is therefore important to consider all three factors: object, immediate background and general surroundings. A variation in any one may alter the ability to see the task.

2.2 — *Fundamentals of Visibility* — Visibility depends upon four fundamental seeing factors:

(a) size of the object of regard or detail,
(b) contrast between the detail and its background,
(c) brightness of the detail and of the background,
(d) time allowed for seeing.

Actually, these four factors are so closely interrelated that it is impossible to discuss one without showing its relationship to the others. One should always be mindful of this fact when analyzing a seeing problem.

2.2.1 —*Size* — **(a)** Large objects are easier to see than small ones, and small objects can be seen in greater detail at close range. Thus, visibility is dependent upon physical size and distance, for constant visibility size must increase in proportion to the distance. Therefore, visual size may be ex-

*This report has been approved by the Committee on Lighting Study Projects in Industry; the personnel is as follows:

A. A. Brainerd, *Chairman*
J. R. Chambers — C. D. Hollister
C. E. Egeler — W. H. Kahler
H. B. Elliott — W. P. Lowell Jr.

Approved by Council letter ballot; reported to Council Executive Committee of the Illuminating Engineering Society, September 15, 1952.

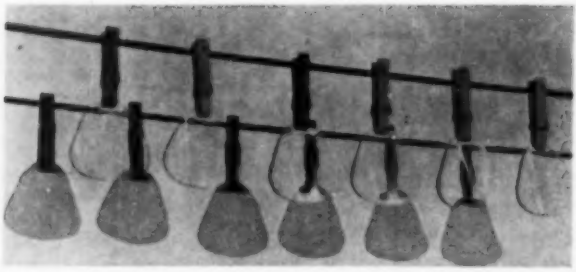


Figure 1. A magnifying lens and additional illumination from built-in fluorescent lamps will improve visibility of small visual tasks (left).

Figure 2. Projection of a beam of light through transparent material will project on a screen imperfection within the transparent material (right).

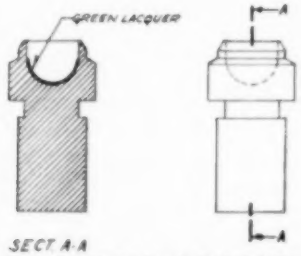


Figure 3. Lighting a hemispherical ball seat to assure accurate perception of the line of demarkation between the green Stoff-off lacquer applied during the operation and the cylindrical lip which must be kept polished and free from lacquer. To eliminate green interreflections which tend to mask the unpainted part of the cavity pink fluorescent lamps are used in industrial type two-lamp lighting units mounted 15 inches above the bench.

Figure 4. (a) A color proof such as this yellow proof (far left) is difficult to examine under white light because yellow details are minimized.

(b) The same yellow proof viewed under blue light (left), the complement of yellow, is easier to examine because the yellow reflects minimum blue and therefore appears dark, creating maximum contrast against the white background.

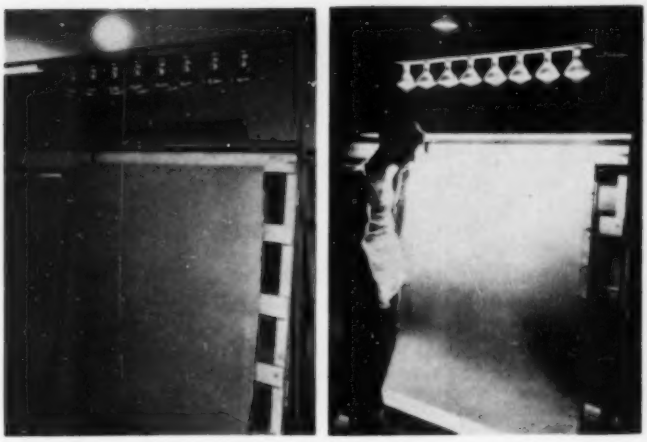


Figure 5. Dents in etched zinc plates are not easy to see (photo at left) with only general room lighting, since illumination is too diffuse. Dents are easily detected when light is applied at a grazing angle to emphasize the shadows of the dents (photo at right).

pressed in terms of the angle subtended at the eye, or "visual angle," generally measured in minutes.

(b) The minimum size of detail recognizable under a certain set of seeing conditions is called "threshold size." This threshold varies widely for different conditions of contrast, illumination, and personal vision. The poor visibility of small detail can be compensated for by increasing the illumination level because smaller threshold sizes are possible under higher illumination levels. The visibility of small detail can also be increased by the use of magnifying lenses. The combination of additional illumination plus a magnifier is a helpful seeing tool for the assembly or inspection of small visual tasks (Fig. 1). Another means of magnifying size of small details is the projection technique. Figure 2 is one example.

2.2.2—*Contrast* — **(a)** High contrast between the detail and its immediate background is essential for maximum visibility. The contrast may be created by differences in brightness, differences in color, or a combination of both. It is well known that certain color combinations create excellent color contrasts, such as blue and gold, and have the added advantage of attraction and decorative appeal. In certain cases it is possible to suggest improvements in task brightness contrast as moderate improvements in contrast may greatly increase visibility. More often task contrast is fixed and visibility can be improved only by applying one of the other factors.

(b) Color, as part of the seeing task, can be effectively used to improve contrast. Black and white are the most desirable combinations for such continual tasks as reading a book, but it has been found that certain color combinations have greater attention value such as black on yellow. The next combinations in order of preference are green on white, red on white, blue on white, white on blue, and finally black on white. Such color combinations are useful where attracting attention to some particular condition is desired.

(c) The color of light can be used to increase contrast by either intensifying or subduing (Fig. 3) certain colors inherent in the seeing task. For example, it has been found that imperfections in chromium plating over nickel plating can be emphasized by using a bluish color of light such as the daylight fluorescent lamp. It has been found also that the color quality from green fluorescent lamps increases the contrast of rust on metal, making the rust easier to see. Visibility of colored printing proofs is greatly improved by using a color of light that is the complement of the color of the ink, Fig. 4.

(d) In addition to differences in reflectance, or color, contrast can be obtained by shadows (Fig. 5) and silhouette as well as such special effects as fluorescence and polarization. Three dimensional objects are seen in their apparent shapes because of the shadows and highlights resulting from certain directional components of light. This directional effect is particularly useful in emphasizing texture and defects on uneven surfaces. Silhouette is an effective means of showing contour. Silhouette letters on a sign and the matching of a template to a shape are examples of this technique for developing contrast.

(e) Fluorescence under untraviolet radiation is often useful in creating contrast. Surface flaws in metal and non-porous plastic and ceramic parts can be detected by the use of fluorescent materials (Fig. 6). Invisible markings as used by laundries are easily seen under ultraviolet.

(f) Polarized light can be used to develop a contrast condition in certain inspection operations. Stresses in glass can be detected by polarized light, and plastic models of mechanical shapes will show the points of strain, Fig. 7.

2.2.3—*Brightness* — The brightness of the task is dependent upon the light reflected from the detail and its background toward the eye. The magnitude of this brightness is determined by the type of lighting and the reflecting characteristics of the task. In most cases brightness is the factor of visibility easiest to control. By increasing brightness, visibility of the task can be improved within limits. Figure 8 illustrates how brightness compensates for poor contrast.

2.2.4—*Time* — **(a)** The time required

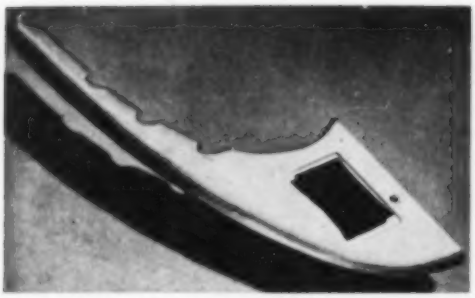


Figure 6. White light view of aluminum casting, apparently not defective.

The same casting. Under black light and a fluorescent penetrant a serious crack is detected in a high stress area.

Minute surface flaws can be easily detected in metal, non-porous plastics and ceramic parts by fluorescent penetrants and black light. A Type S-I directional concentrating luminaire is required. A mercury projector spot lamp plus a black light filter is often recommended for this application.

Figure 7. Photoelectric polariscope aids in pretesting design of mechanical parts by revealing stress patterns in plastic models. From left to right, light from a 250-watt mercury lamp projector passes through a concentrating lens, polarizing screen, transparent model being tested, another polarizing screen, camera lens and the image is projected on the ground glass or film of the camera. The polarized light on the camera ground glass will show the distribution of stresses in the model (inset).

Figure 8. High brightness compensates for poor visibility. The welder can see through his welding lens to locate the welding rod aided by 6000 ft-c from two spot lamps.

Figure 9. Stroboscopic light will visually stop the motion of rotating equipment. This device is useful in balancing machine parts, and measuring speed.

Figure 10. **Balanced distribution of brightness with general plus supplementary lighting for high visibility critical seeing tasks.**

TABLE I.—Recommended Brightness Ratios.

3 to 1 between tasks and adjacent surroundings
20 to 1 between tasks and more remote surroundings
40 to 1 between luminaires (or sky) and surfaces adjacent to them
80 to 1 anywhere within the environment of the worker

TABLE II.—Recommended Light Reflectances for Interior Surfaces.

Reflection Factor	
Ceiling	80%
Walls	60%
Desk and bench tops	35%
Machines and equipment	25-30%
Floors	Not less than 15%

to see a certain task is influenced within limits by size, contrast and brightness. A task of large size, of high brightness, and with high brightness contrast can be seen most rapidly. Often brightness can be increased and thus the task may be seen more accurately within a limited time. The possibility of increasing contrast should never be overlooked, for high contrast is a very important contributor to minimizing the seeing time required.

(b) While high illumination levels lead to the maximum rate of vision, rapidly moving objects such as a rotating wheel generally cannot be seen in detail. However, if the light source flashes with pulsations of the same frequency as the rotating wheel, the apparent speed of the wheel can be reduced or actually stopped and then the object can be seen in detail. Special stroboscopic light sources are available for this purpose (Fig. 9).

(c) For most uses of supplementary lighting equipment it is desirable to minimize variations of light output due to cyclic current variations. This prevents the annoyance of viewing moving parts which appear to move erratically.

2.3 — *Fundamentals of Comfort* — **(a)** Visual comfort is a function of brightness and color of the task in relation to the brightness and color of the complete surroundings. High brightness contrast between detail and the immediate surroundings is necessary for good visibility of the detail, but the brightness relationship between the task as a whole and adjacent surroundings should be controlled. This relationship is called brightness ratio and is the ratio of task brightness to surrounding brightnesses. For critical and prolonged seeing tasks in industry the brightness ratios in Table I should not be exceeded.* To attain these limits of brightnes ratio it is necessary to coordinate the design of the supplementary lighting with the general lighting system (Fig. 10). Thus, when planning supplementary lighting, consideration must be given to the general lighting and the light reflecting characteristics of all surfaces within the field of view.

(b) The observer should be protected from direct view of high brightnesses such as bright windows and exposed light sources. Wide differences in brightness, such as a bright window as seen against a dark adjacent wall, should also be avoided.

(c) Reflections of high brightness from specular surfaces should usually be avoided; such reflections are very annoying. However, for certain types of display or inspection work, this reflected brightness can be used to advantage; for example, in the display of jewelry or in separating coal and slate on the picking table. The reflections of low brightness sources are used extensively in both the inspection and display fields. When these low brightness reflections are required, they can be produced by a source of large physical size, or by mounting a smaller source at a close distance. It is easier to examine critically specular or semi-specular surfaces when a uniform, low brightness reflection provides a luminous background against which defects in the surface are readily seen. In some cases this technique is modified by employing a regular contrasting pattern on the surface of the large area low brightness source. The reflection of this pattern from a specular surface will indicate any irregularity by distorting the reflected image of the pattern.

(d) The use of strong colors (high chroma) should be approached with caution; in general large expanses of strong color are to be avoided. Most psychologists agree that grayed, pastel colors create little emotional reaction and therefore are not disturbing or distracting. Since it is desirable to create a quiet restful visual environment in a working area, the brightness pattern should be relatively uniform and the color scheme should utilize the non-emotional pastel colors. For special effects, such as displays and for decoration, strong colors can be used for their attention values.

(e) Table II gives the recommended

*These are considered as maximum for industry. It is desirable to approach the ratios set up for office and school interior: 3 to 1, 10 to 1, 20 to 1, and 40 to 1 respectively.

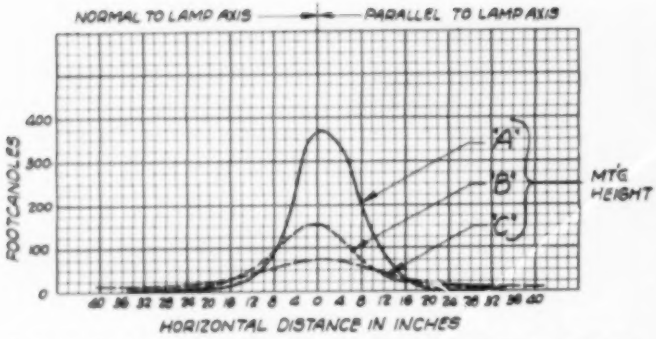


Figure 11. Typical illumination data from a supplementary luminaire. Data such as these are very helpful to the lighting application engineer.

reflectance values for various interior surfaces.

3. Supplementary Lighting Equipment

3.1 — ***General*** — A wide variety of lighting equipments can be used for supplementary applications ranging from conventional general lighting units to luminaires designed for very specific requirements. Regardless of the nature of the equipment certain illumination characteristics are important to the illuminating engineer and should be provided by the manufacturers. The four basic illumination characteristics important to all types of equipments are listed and discussed below:

(a) candlepower distribution and brightness classification
(b) footcandle distribution data
(c) shielding
(d) luminous dimensions.

3.2 — ***Classification of Luminaires*** — Supplementary lighting units can be classified in five major types according to candlepower distribution and brightness.*

Type S-I — The directional type includes all concentrating units. Examples are reflector spot-lamps or units employing concentrating reflectors or lenses. Also included in this group are concentrating longitudinal units such as a well-shielded fluorescent lamp in a concentrating reflector.

Type S-II — The spread, high brightness type includes all widespread units having a maximum brightness of 400 footlamberts and over. A deep bowl diffusing reflector with a filament lamp and without diffusing cover is an example of this type.

Type S-III — The spread, moderate brightness type includes all units having a maximum brightness of less than 4000 footlamberts and with a variation in brightness of more than 2 to 1. A direct fluorescent luminaire is an example of this type.

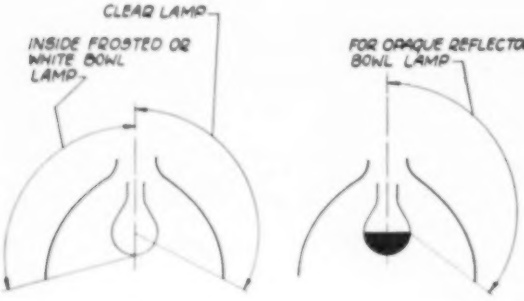
Type S-IV — The uniform brightness type includes all units having less than 2 to 1 variation of brightness. Examples of this type are an arrangement of fluorescent lamps behind a diffusing panel or an illuminated reflecting panel.

Type S-V — The uniform brightness type with a pattern is a luminaire similar to Type IV except a pattern of stripes or lines is superimposed on the uniform, low brightness area of the unit.

*This classification is unique to this Practice and has no relation to C.I.E. (International Commission on Illumination) or to commercial and industrial general lighting luminaires.

3.3 — ***Footcandle Distribution*** — The footcandle distribution of supplementary equipment should be shown in the form of a series of footcandle curves or charts at three typical distances from the unit (Fig. 11). The data should be for rated initial lamp output and the type and size of lamp used should be noted with the curves. Measurements should be made in planes perpendicular to direction of maximum candlepower at distances measured between the plane and nearest point of the luminaire. For some special applications illumination in certain angular planes is required; measured or calculated data for such cases should specify all of the test conditions.

3.4 — ***Shielding*** — Shielding is that portion of the solid angle between nadir and 180 degrees through which the source is not visible. It should be specified by the limiting angles. (See Fig. 12.) If the unit is not symmetrical, maximum and minimum shielding should be shown. The light source is considered as the edge of the lamp, with the exception of a clear bulb where the source is considered to be the light center. In the case of the



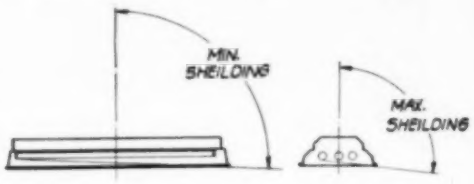


Figure 12. (a) Shielding for symmetrical luminaire (left). (b) Shielding for non-symmetrical luminaire (below).

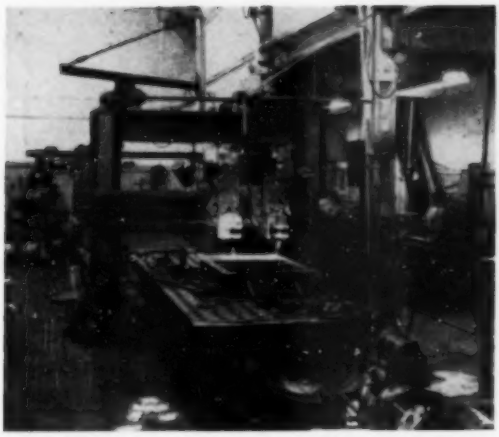


Figure 13. Lighting for a movable-bed planer must be sturdy to withstand mechanical shocks and jars, must not interfere with material handling crane and should be protected from flying chips of metal. Two spot lamp units are mounted on adjustable arms which are supported by a swinging boom, permitting removal when crane is used.

Figure 14. Diffuse detail on a diffuse background such as pencil lines on wood can be illuminated with either high or low brightness luminaires, an important consideration in prevention of direct glare and shadows.

opaque reflector bowl lamp or its equivalent with a separate reflector, the shielding should be measured to the point at which the luminous portion of the lamp becomes visible. While the light source location with respect to the reflector edge is considered in specifying shielding angle, it should be noted that diffuse reflectors, lenses, and louvers may become the secondary light source creating objectionable brightness; therefore, care should be used in applying these types of equipment. For most applications, supplementary lighting equipment should have a shielding angle from less than 90 to 180 degrees.

3.5—***Luminous Dimensions***—Luminous dimensions are extremely important in Types II, IV and V; it is necessary to specify size and shape when a unit is used to produce a reflected image of a certain size on the work.

3.6—***Physical Characteristics***—In addition to the illumination characteristics of a supplementary luminaire, there are a number of mechanical factors to consider in selecting the equipment.

3.6.1—*Adjustability*—Methods of

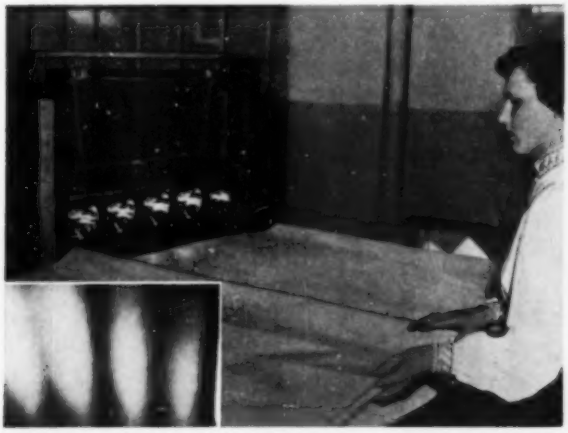


Figure 15. Paper inspection involves a diffuse surface with diffuse detail. Wrinkles and other surface imperfections are emphasized with directional light, luminaire Type S-I. Inset shows how wrinkles are accentuated by low angle lighting.

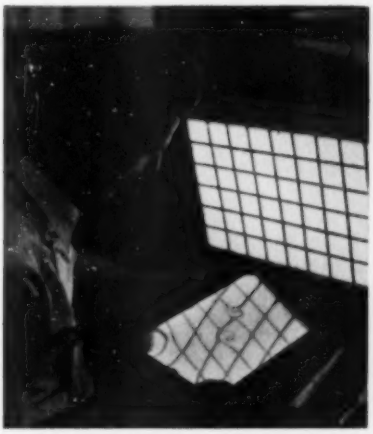


Figure 16. A dent or warp in sheet metal involves specular detail on a specular background. Detail is easily seen as distortion of a reflected pattern, luminaire Type S-V.

Figure 17. Rear view (upper left) and front view (upper right) of punch press illuminated to provide a luminous image from the die and sheet metal stock will give high visibility of detail and any pieces of scrap remaining on the die will be seen silhouette. Here the luminous image is provided by the combination of an angle reflector and white paint on the inner sides of the press. Reflector is supported on a shock absorbing hanger to protect the lamp from shock. Reflector must be located so that bare lamp image is directed below the operator's line of sight.

Figure 18. Engraving on a copper plate involves visibility of the specular cuts on a specular background. Proper orientation of luminaire Types S-I, S-II or S-III will create a contrast of bright engraving cuts against a dark background.

Figure 19. Scribe lines on a specular steel block represent specular detail and specular background. Here illustrated luminaire Type S-II is adjusted so scribe lines appear bright against a dark background.

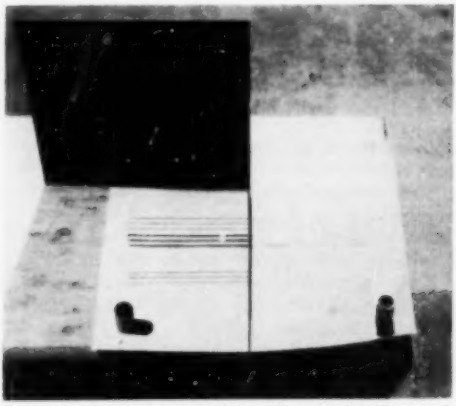


Figure 20. Drafting paper with pencil and inked lines under high brightness sources.

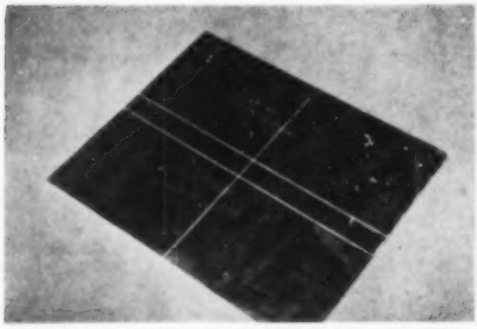


Figure 21. Scribe marks on a blued steel plate are specular details on a diffuse background. Luminaire Types S-I, S-II or S-III should be located to reflect brightness from the scribe lines to the eye.

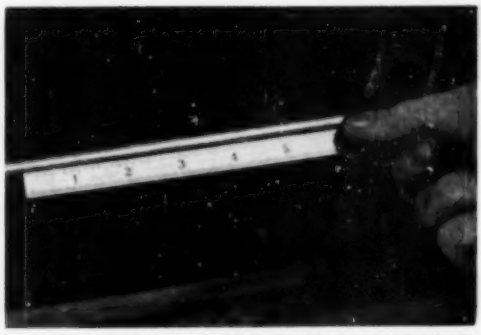


Figure 22. A steel scale is diffuse detail on a specular background. The moderate brightness, S-III, or uniform brightness, S-IV, luminaires will be reflected from the specular background to create maximum contrast for details.

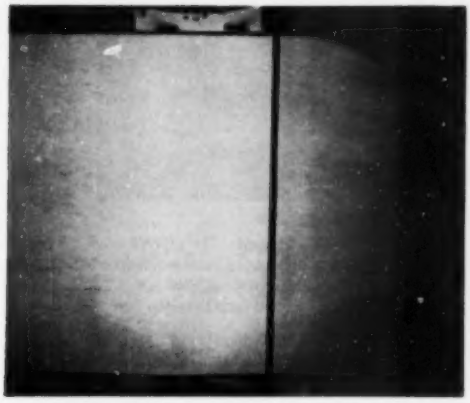


Figure 23. Translucent materials such as light weight fabrics can be easily inspected with a Type III or IV luminaire mounted behind the fabric.

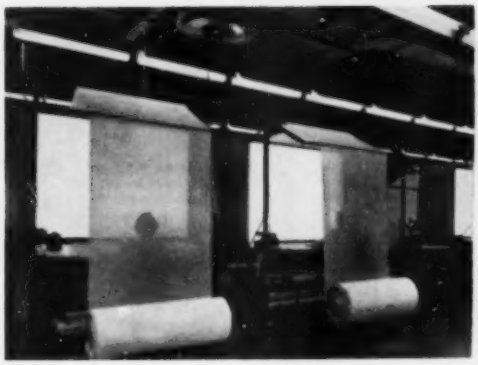


Figure 24. Rayon cloth is inspected for flaws in weaving. The fabric is passed between the light source (luminous panel lighted with 24 fluorescent daylight lamps) and the inspector, holes being detected by the change in brightness between the holes and the surrounding material.

mounting supplementary luminaires may be divided into three classifications:

(a) *Fixed* — Wherever possible supplementary luminaires should be permanently mounted in a location to produce the best overall results. For these applications a fixed mounting should be provided.

(b) *Semi-adjustable* — The facility for adjustment should be mechanically secure so that units can be positioned as required in a rigid manner (Fig. 13).

(c) *Adjustable* — Supplementary lighting is often used for a variety of seing tasks so the luminaires must be arranged with the necessary adjustable features to permit the proper position for each seeing task.

3.6.2—*Portability*—While supplementary equipment should be permanently mounted wherever the job location is fixed, there are many applications that require portability. Luminaires designed for this purpose should be electrically and mechanically rugged commensurate with the intended service. Lamps should be guarded where subject to breakage and should be shielded as well as practicable for the benefit of the user and other workers.

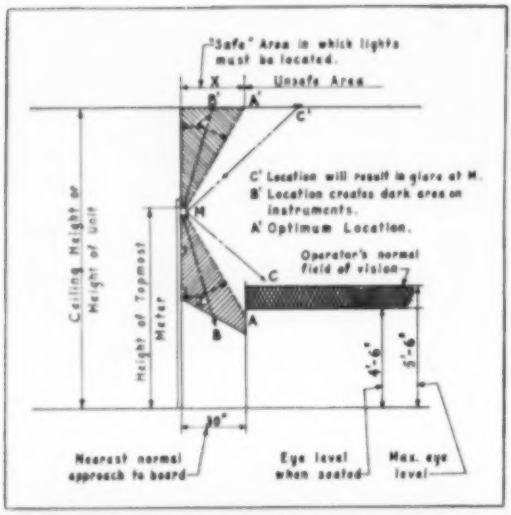
3.6.3—*Physical Dimensions* — Space limitations are often an important factor in the installation of supplementary equipment. Therefore, the manufacturer should supply complete physical dimensions so that proper positioning of equipment can be planned. Manufacturer should also supply data on the range of adjustment.

3.6.4—*Resistance to Vibration* — Particular attention should be given to vibration resistance when luminaires with adjustable arms are used because the luminaires should remain in the desired position even under vibration conditions. When a machine creates severe vibration it is best to mount the luminaire completely separate from the machine so that vibration is not transmitted directly to the lamp. If separate mounting is impractical the design of the luminaire as well as the lamp should be such to withstand this vibration.

3.6.5—*Resistance to Shock or Impact*—Practically all portable types of supplementary lighting units are subject to shock or impact to some degree. Therefore, such portable units should be designed to withstand the most severe abuse that is given to portable units; it can be expected that such units will be dropped and that tools will be allowed to fall on them.

3.6.6—*Discomfort Heat*—With the demand for high levels of supplementary lighting, the high wattage lamps required often create surface temperatures on the luminaire which are considerably above the limits of comfort for the person who must handle it. In fact, with poor design the temperatures are often sufficient to cause burns if the operator is not particularly careful. Such a condition is unsafe and should not be permitted. Therefore, proper protective means should be provided for the luminaire in the way of heat insulators, handles, or other devices which will protect the user. Consideration must also be given to radiant heat, as high wattage sources may cause discomfort to workers. The major zone of discomfort due to radiant energy is in the beam of

Figure 25. Transparent material can be inspected for interior and surface defects by edge lighting. When the material is viewed against a dark background, defects appear as bright spots in the material. The light comes from a fluorescent lamp mounted behind a slot in the box.



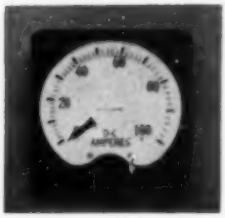


Figure 26. Instruments are typical of a transparent material over an opaque surface. Direct lighting must be located to prevent reflected glare. A shallow instrument will minimize the top shadow.

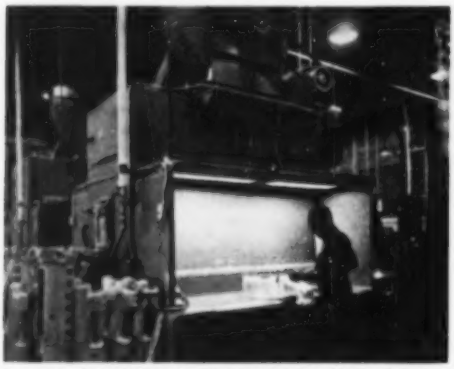


Figure 27. Inspection of castings involves diffuse detail and background. Here Type III luminaires are used to prevent direct glare and shadows.

Figure 28. Diffuse detail and background, with poor contrast is typified in the under carriage of public and private vehicles. Here Type S-III luminaires combine with white walls to prevent direct glare and harsh shadows.

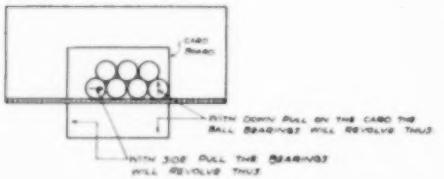


Figure 29. Scratches and pits on ball bearings represent specular detail and background. Here a white box serves as a Type IV luminaire, being reflected by the bearings and showing up pits, scratches and insufficient plating. The surfaces of the box are illuminated by a lamp in a reflector located to shield the lamp from the operator's view.

the concentrating type of equipment. If possible these units should be located so that beams are not directed on the workers.

3.6.7—*Maintenance*—Like all lighting equipment supplementary units should be frequently cleaned to maintain maximum light output. It is generally easy to clean such units because they are within close reach of the user. The luminaire should be so designed that the reflector and lamp are easily accessible without removal of small loose parts or completely dismantling the luminaire.

TABLE III.—Classification of Visual Tasks and Lighting Techniques.

PART I — FLAT SURFACES

Classification of Visual Task	Example		Lighting Technique	
General Characteristics	**Description**	**Lighting Requirements**	**Luminaire Type**	**Locate Luminaire**
A. Opaque Materials				
1. Diffuse detail & background				
a. Unbroken surface	Pencil marking on wood (Fig. 14) Newspaper proof reading, paper inspection (Fig. 15)	High visibility with comfort	S-III or S-II	To prevent direct glare & shadows (Fig. 36a)
b. broken surface	Scratch or chip on unglazed tile	To emphasize surface break	S-I	To direct light obliquely to surface (Fig. 36c)
2. Specular detail & background				
a. Unbroken surface	Dent, warps, uneven surface (Figs. 16, 17)	Emphasize unevenness	S-V	So that image of source & pattern is reflected to eye (Fig. 36d)
b. Broken surface	Scratch, scribe, engraving, punch marks (Figs. 18, 19)	Create contrast of cut against specular surface	S-III	So detail appears bright against a dark background
			or S-IV or V when not practical to orient task	So that image of source is reflected to eye & break appears dark (Fig. 36d)
c. Specular coating over specular background	Inspection of finish plating over under plating (Fig. 27)	To show up uncovered spots	S-IV with color of source selected to create maximum color contrast between two coatings	For reflection of source image toward the eye (Fig. 36d)
3. Combined specular & diffuse surfaces				
a. Specular detail on diffuse, light background	Shiny ink or pencil marks on dull paper (Fig. 20)	To produce maximum contrast without reflected glare from shiny markings	S-III or S-IV	So direction of reflected light does not coincide with angle of view (Fig. 36a)
b. Specular detail on diffuse, dark background	Punch or scribe marks on dull metal (Fig. 21)	To create bright reflection from detail	S-II or S-III	So direction of reflected light from detail coincides with angle of view (Fig. 36b)
c. Diffuse detail on specular, light background	Graduations on a steel scale (Fig. 22)	To create a uniform, low brightness reflection from specular background	S-IV or S-III	So reflected image of source coincides with angle of view (Fig. 36b or d)
d. Diffuse detail on specular, dark background	Wax marks on auto body	To produce high brightness of detail against dark background	S-III or S-II	So direction of reflected light does not coincide with angle of view (Fig. 36a)
B. Translucent Materials				
1. With diffuse surface	Frosted or etched glass or plastic, light weight fabrics, hosiery (Figs. 23, 24)	Maximum visibility of surface detail	Treat as opaque, diffuse surface—See A-1	
		Maximum visibility of detail within material	Trans illuminate behind material with S-II, S-III or S-IV (Fig. 36e)	
2. With specular surface	Scratch on opal glass or plastic	Maximum visibility of surface detail	Treat as opaque, specular surface—See A-2	
		Maximum visibility of detail within material	Trans illuminate behind material with S-II, S-III or S-IV (Fig. 36e)	
C. Transparent Materials Clear material with specular surface	Plate glass	To produce visibility of details within material such as bubbles & details on surface such as scratches	S-V and S-I	Transparent material should move in front of Type S-V, then in front of black background with Type S-I directed obliquely. Type S-I should be directed to prevent reflected glare. (Fig. 25)
D. Transparent over Opaque Materials				
1. Transparent material over diffuse background	Instrument panel (Fig. 26)	Maximum visibility of scale & pointer without reflected glare	S-I	So reflection of source does not coincide with angle of view
	Varnished desk top	Maximum visibility of detail on or in transparent coating or on diffuse background		
		Emphasis of uneven surface	S-V	So that image of source & pattern is reflected to the eye (Fig. 36d)
2. Transparent material over specular background.	Glass mirror	Maximum visibility of detail on or in transparent material	S-I	So reflection of source does not coincide with angle of view. Mirror should reflect a black background (Fig. 36a)
		Maximum visibility of detail on specular background	S-V	So that image of source & pattern is reflected to the eye (Fig. 36d)

Figure 30. Specular detail and background is exemplified in the task of checking chromium plating over nickel plating. This Type IV luminaire with daylight fluorescent lamps facilitates the detection of poor coverage of the chromium by emphasizing difference in colors of chromium and nickel.

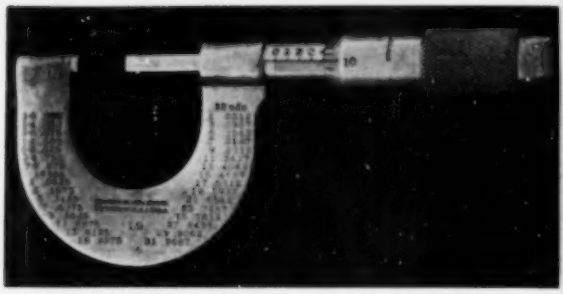


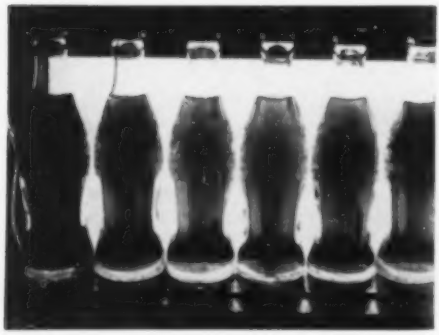
Figure 31. Three dimensional objects with diffuse detail and specular background require S-IV or S-III luminaires to produce the luminous background reflection. The size of the source is considerably greater than with flat surfaces (Fig. 15) because the curved barrel diminishes source reflection.

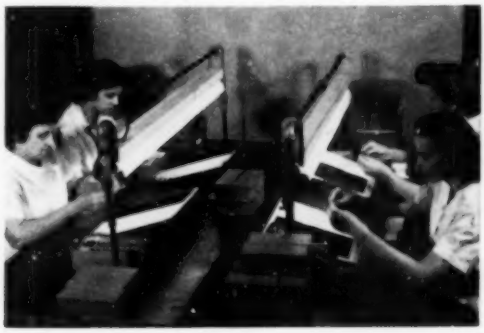
Figure 32. Contrast by Low Brightness Reflection. This indirectly illuminated light hood serves two purposes essential to better visibility. The low brightness and large area characteristic provide excellent visibility of verniers because scale markings have good contrast against the luminous reflected image of the source. The hood is large enough to to shield out direct brightness of skylights and fluorescent lamps and thus prevent reflected glare.

Figure 33. Coal picking involves diffuse detail and specular background as dull slate and shale must be picked from the shiny coal. With high brightness luminaires, Types S-I or S-II, the coal glitters in contrast to the dull impurities.

Figure 34. Translucent objects such as an inflated balloon can be easily inspected for defects by trans-illumination with a Type S-IV luminaire.

Figure 35. (below) Clear liquids in transparent containers can be inspected by transillumination, luminaires S-IV or S-V. Below left, bottles are inspected against a Type S-IV luminaire. Below right, vials of anesthetic are examined against background of opaque black and white mats which serve as a Type V luminaire. Inspections are made by looking through the vials, first at the black background which discloses any light-colored sediment; then at the white background which makes visible any dark sediment.





Classification of Visual Task	Example		Lighting Technique	
General Characteristics	Description	Lighting Requirements	Luminaire Type	Locate Luminaire
A. Opaque Materials				
1. Diffuse detail & background	Dirt on a casting or blow holes in a casting (Fig. 27) Miscellaneous seeing tasks (Fig. 28)	To emphasize detail with a poor contrast	S-III or S-II or	To prevent direct glare & shadows (Fig. 36b)
			S-I or	In relation to task to emphasize detail by means of highlight & shadow (Fig. 36c)
			S-III or S-II as a black light source when object has a fluorescent coating	To direct ultra-violet radiation to all points to be checked
2. Specular detail & background				
a. Detail on the surface	Dent on silverware	To emphasize surface unevenness	S-V	To reflect image of source to eye (Fig. 36d)
	Inspection of finish plating over underplating (Fig. 30)	To show up areas not properly plated	S-IV plus proper color	To reflect image of source to eye (Fig. 36d)
b. Detail in the surface	Scratch and pits on ball bearings (Fig. 29)	To emphasize surface break	S-IV	To reflect image of source to eye (Fig. 36d)
3. Combination specular & diffuse				
a. Specular detail on diffuse background	Scribe mark on casting	To make line glitter against dull background	S-III or S-II	In relation to task for best visibility. Adjustable equipment often helpful
b. Diffuse detail on specular background	Micrometer scale (Fig. 31)	To create luminous background against which scale markings can be seen in high contrast	S-IV, S-III	Overhead to reflect image of source to eye (Fig. 36d)
	Vernier scales (Fig. 32)			With axis normal to axis of micrometer
	Coal picking	To make coal glitter in contrast to dull impurities	S-I, S-II	To prevent direct glare (Fig. 36b)
B. Translucent Materials				
1. Diffuse surface	Lamp shade, balloons (Fig. 34)	To show imperfections in material	S-II	Behind or within for trans-illumination (Fig. 36e)
2. Specular surface	Glass enclosing globe	To emphasize surface irregularities	S-II	Overhead to reflect image of source to eye (Fig. 36d)
		To check homogeneity	S-V	Behind or within for trans-illumination
C. Transparent Materials				
Clear material with specular surface	Bottles, glassware — empty or filled with clear liquid (Fig. 35)	To emphasize surface irregularities	S-I	To be directed obliquely to objects
		To emphasize cracks, chips & foreign particles	S-IV or S-V	Behind for trans-illumination. Motion of objects is helpful (Fig. 36e)

3.6.8 *Specific Atmospheric Conditions* — Since supplementary units are generally used in close proximity to a production operation, they may be subjected to severe atmospheric conditions, such as oil mist, dust, corrosive vapors, explosive dust or vapor mixtures. The lighting engineer should be thoroughly familiar with the atmospheric conditions present and should specify luminaires suitable for the particular conditions. If hazardous or explosive vapors are present, the National Electrical Code provides definite specifications for lighting equipment for use in these areas. The lighting engineer should consult the local inspection authorities and code before specifying equipment for this class of service.

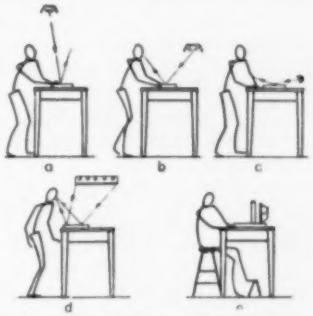


Figure 36. Examples of luminaire placement.

(a) Luminaire located to prevent direct glare and shadows or reflected glare; reflected light does not coincide with angle of view.

(b) Reflected light coincides with angle of view.

(c) Low-angle lighting to emphasize surface irregularities.

(d) Large-area surface source and pattern are reflected toward the eye.

(e) Transillumination from diffuse source.

4. Classification of Visual Tasks and Lighting Techniques

Visual tasks are unlimited in number but can be classified according to certain common characteristics. The detail to be seen in each group can be emphasized by an application of certain lighting fundamentals. Table III classifies tasks according to their physical and light controlling characteristics and suggests lighting techniques for good visual perception.

It should be noted, when using this table, that the classification of visual tasks is based on the prime and fundamental visual task characteristics and not on the general application. For example, on a drill press the visual task could be the discernment of a punch mark on metal. This could be specular detail with a diffuse, dark background, classification A-3(b) in the table. Luminaire Types S-II or S-III are recommended. S-II on an adjustable arm bracket is a practical recommendation due to space limitations.

Questions and Answers on light sources

The I.E.S. Committee on Light Sources, under the chairmanship of E. H. Raddin, has prepared this listing of answers to frequently-asked questions. Readers are invited by the Committee to submit similar questions of general interest on light sources, to be considered for publication from time to time. Questions may be sent in care of Society Headquarters.

What effect has flashing on and off on the life of general service incandescent filament lamps?

Any reduction in life due to flashing *under ordinary* circumstances has been generally considered as negligible from a commercial point of view. Academically, it can be argued that due to current overshoot repeated flashing would take something out of lamp life. However, the amount of overshoot never anywhere nearly approaches the theoretical value as calculated from the ratio of hot to cold resistance of tungsten (12 or 15-to-1). This is because the resistance of the circuit reduces the instantaneous overshooting appreciably. If the flashing is at such a rate that the filament is never allowed to cool completely, the effect due to instantaneous overshoot is further reduced. The construction of the filament and the wattage of the lamp, which affect the heat storage capacity of the filament, are additional variables.

What is the life expectancy of a good quality 40-watt 2-lamp brick-type ballast under normal conditions?

Other things being equal, the life of a ballast is dependent upon conditions of use. If so operated as to avoid excessive voltage and temperature, the average life of ballasts of this type should be of the order of 15 years. Individual ballasts may, of course, give lives well in excess of this average as well as markedly below it.

Does the output of a carbon arc diminish during the life of the electrodes?

The output of the carbon arc is not affected by the time of burning or the length of electrodes remaining. With a good burner mechanism, the arc voltage and current are held constant to maintain a constant light output throughout the life of the carbons.

Do color-corrected mercury vapor lamps in which correction is achieved by means of a phosphor maintain their initial degree of color-correction during the useful life of the lamp?

Tests made on 400-watt color-corrected mercury vapor lamps of the JH-1 type over several thousands of hours of operation have indicated that the proportion of the red energy in the light output throughout the life of fluorescent-mercury lamps remains substantially constant.

What is the difference between Street Series incandescent filament lamps and Group Replacement Street Series incandescent filament lamps?

The primary difference is in rated life, the so-called "regular" street series lamp being designed for 2000 hours life and the group replacement lamp for 3000 hours life. The group replacement lamp is designed to have the same initial light output as the comparable regular street series lamp. The lamp watts of the 3000-hour lamp must be greater to produce light output equal to the 2000-hour lamp. For example: the 2500-lumen, 6.6-ampere, 2000-hour lamp consumes initially 143 watts while the same 3000-hour lamp has an initial rating of 149 watts. Refer to *IES Lighting Handbook*, Second Edition, page 8-65.

What determines the end of the period of usefulness for high intensity mercury lamps?

Lamps should be replaced when a footcandle meter at the working surface indicates that illumination received at the surface is less than that specified for the particular type of work in progress. It should be noted that many lamps may continue to operate satisfactorily long after this condition of illumination has been attained. In general, old lamps should not be used after their output has decreased to 60 per cent of their initial rating.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

First Council Meeting New Administration Meets in New York

The 1952-1953 Council of I.E.S., which took office October 1st, held its first meeting October 10 at the Lexington Hotel, New York City, with 27 attending. I.E.S. President E. M. Strong presided. In addition to Professor Strong, those attending were: Past Presidents S. G. Hibben and Walter Sturrock; Vice-Presidents Duncan M. Jones and A. H. Manwaring; General Secretary C. C. Keller; Treasurer Kirk M. Reid; Directors M. H. Waterman, proxy for Charles R. Long; L. H. Graves, proxy for Roy A. Palmer; J. S. Schuchert; J. F. Whitehead, Jr.; F. C. Winkler; Regional Vice-Presidents P. H. Hildebrand, L. C. Twitchell, C. H. Goddard, proxy for Harold T. Rankin, L. B. Paist, George J. Taylor, S. B. Williams, proxy for Walter J. Lind, R. Cecil Paslay, N. D. MacDonald, proxy for L. A. Hobbs, and W. E. Folsom; A. D. Hinckley, Executive Secretary; C. L. Crouch, Technical Director; Ruby Redford, Editor; C. E. Ellis, Advertising and Promotion Manager; and R. F. Hartenstein and H. P. Steele.

A brief summary of pertinent action taken follows:

On recommendation of the Executive Committee, Council approved the appointment of H. T. Rankin, Denver, Colo. as the first Regional Vice-President of the new Inter-Mountain Region. This brings to ten, the Regions of I.E.S. in the United States and Canada, represented on the Council. The new Inter-Mountain Region, which will be under the direction of Mr. Rankin to Sept. 30, 1953, embraces the Rocky Mountain Section, Utah Chapter, Southern Colorado Chapter, Arizona Chapter and the New Mexico Chapter.

National Conferences Set

Hoyt P. Steele, Chairman of the National Technical Conference Committee, reported to Council on the outcome, financially and in other respects, of the recent National Technical Conference held in Chicago. He recommended that the present committee extend its current study and work through the 1956 Conference. He noted that all Regional Vice-Presidents were in close touch with plans as discussed by the Committee and further reported discussions of his committee on a number of invitations from several Sections and Chapters for Conference locations in the next several years. Study of some six invitations resulted in a recommended schedule of Conference cities as follows:

1954	Atlantic City
1955	Cleveland, Ohio
1956	Boston, Mass.
1957	Atlanta, Ga.
1958	Toronto, Canada.

Mr. Steele's recommendation was accompanied by full details of his committee's considerations in recommending these locations. Considerable study was devoted to the subject by Council, culminating in action approving these locations through 1958.

Public Relations

Plans for the Society's program of Public Relations and Information were outlined by J. S. Schuchert, Chairman of that committee. He noted that as drawn up at their meeting October 8, comprehensive program was planned for next year within the framework of the committee personnel and headquarters staff without engaging outside services.

Four New Chapters

As part of his report on Local Activities, Duncan M. Jones, Chairman, reported that four Chapters and a Student Branch had prepared petitions for Charters. He called on Vice-Presidents of the several groups to present these petitions.

A petition from an active group of members in San Jose, Calif. was presented by A. D. Hinckley, Executive Secretary, for L. A. Hobbs. The petition noted a series of 12 evening classes in illumination initiated and conducted by this group last spring, under the direction of John S. Walsh as Chairman. Action of Council approved a Charter for the San Jose Chapter.

The petition from groups in Duluth and Superior, Wis., was presented by L. B. Paist, Regional V-P, for a Charter for a Chapter, with headquarters in Duluth, to be known as the Twin Ports Chapter.

He noted the group has the endorsement of the Twin City Section and the Regional V-P, that temporary officers have been appointed and By-Laws discussed. Council action approved Charter to the Twin Ports Chapter.

A Victoria, B. C. group petitioned for Charter through Regional V-P Walter J. Lind, presented in Mr. Lind's absence by A. D. Hinckley. This group has been active for several years and served as host to the Regional Conference last spring. The petition, signed by the group's pro-tem officers, was approved.

Petition for Charter, from a group in Memphis, Tenn., was made through R. C. Paslay, Southern Regional V-P. Mr. Paslay noted the group's work during the past several years, as the Mid-South Illumination Club, and presented Minutes of four recent meetings. Favorable action of Council granted a Charter to this group, with the Charter name to be considered later.

A new Student Branch in Memphis also petitioned through Mr. Paslay, by students of the Southern College of Optometry in Memphis. Formation of this group was approved.

Committee Appointments

A list of suggested Committees was discussed, and with revisions action was taken to approve these appointments. A complete list of 1952-1953 Committee personnel will be published in the December issue of IE.,

Technical Program

The Society's technical program was reported by A. H. Manwaring, Senior V-P, and C. L. Crouch, Technical Director. They called special attention to a meeting scheduled for November 21 and 22 in Buffalo, N. Y., to which all of the chairmen of the technical committees will be invited to attend a Technical Committee Forum to correlate the Society's whole technical committee program. In connection with this meeting, a clinic will be held on Measurement Instruments.

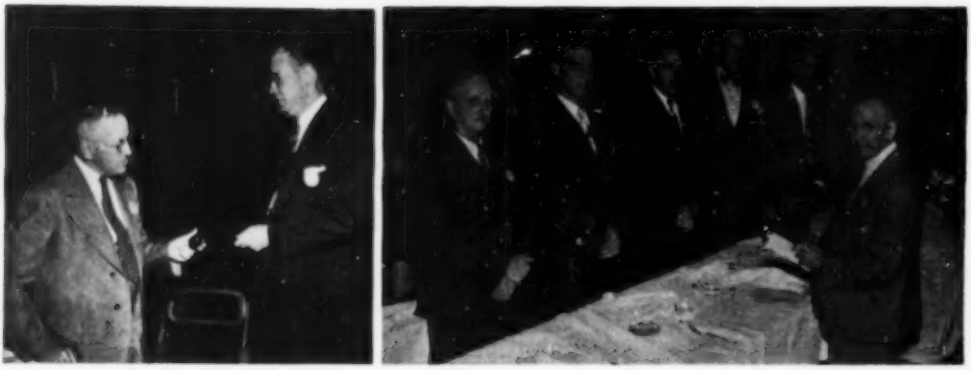
Mr. Crouch also reported the I.E.S.

Here and There with I.E.S. Members

MEETING of the St. Louis Section had retiring President S. G. Hibben as featured speaker. Standing with Mr. Hibben are L. M. Wallace, Jr., incoming Chairman, John J. Rhoades, retiring Chairman, and Brooks Chassaing, Chairman of the Program Committee.

PARTICIPANTS in the lighting session of the Pacific General Meeting of the American Institute of Electrical Engineers were three I.E.S. members, l. to r., Barney H. Hartley, retiring Chairman, Arizona Chapter; Benjamin S. Benson, guest speaker; J. D. Whitnell, incoming Chairman of the Arizona Chapter. The Chapter was invited by A.I.E.E. to present the program of the lighting session.

ALUMNI of the Illumination Option at the University of Illinois had a get-together dinner September 10, while at the Chicago Conference. Standing, are R. D. Burnham, A. Rosenstein, W. Benjamin, W. N. Mangold, A. S. Levine, Professor W. E. Miller, W. D. Richards, G. M. Marks, R. M. Hall, A. H. Gott, E. H. Witte and D. Campbell; seated, R. E. Wozniak, C. J. Pudewill, E. Lozano, L. J. Coleman, E. Neckopolos, A. E. Leavitt, J. DeVore, V. Polton and J. Burke. In addition to Professor Miller, Professors John Kraehenbuehl and Harry W. Horn were invited guests of honor, but were unable to attend.



INSTALLATION of Section Chairman and Board of Managers for the Southern California Section is done by Wm. P. (Teddy) Bear, Member Emeritus. At left he presents the gavel of office to Chairman Roy E. Dahlin and at right he installs the Section Board of Managers, C. E. Mauk, F. E. Blair, W. J. Stewart, R. H. Kreyser and S. H. Simonsen.

project underway with the Textile Industry in which a study is being made of the seeing conditions in textile mills. Numerous other technical committee activities were outlined for Council's information.

PUBLICATIONS COMMITTEE

In the absence of E. C. Huerkamp, retiring Chairman of the Publications Committee, C. E. Ellis, Advertising and Sales Promotion Manager, and Ruby Redford, Editor, reported on the Publications program for the past year. Mr. Ellis presented a chart showing the financial operation indicating that the Society's magazine, ILLUMINATING ENGINEERING, has operated well within budget in spite of the some ten per cent increase in editorial content reported by Miss Redford. They reported plans underway for the coming year further expanding the journal's interest to the entire membership.

MEMBERSHIP STATISTICS

The Board of Examiners, Eugene Fahey, Chairman, recommended for election nine new members and five reinstatements and the transfer from Associate to Full Member of 27 Associate Members. Council acted favorably on these elections. For Council's information the Board of Examiners reported their election of 96 Associate Members and 5 Student Members. Following action taken as reported, the membership totals are shown in the following tabulation:

September 30, 1952		October 9, 1952
7394	Total Membership	7479
34	Members Emeritus	23*
41	Fellows	55
1797	Members	1819
5293	Associate Members	5339
229	Student Members	233

*Included 11 Fellows.

COUNCIL MEETING DATES

Council approved a schedule calling for Council Meeting on December 11, 1952 in New York City, February 12, 1953 in New York City. The date and location for the April meeting of Council was tabled pending a canvas of Council members, as to whether it would be feasible to meet in Dallas instead of New York.

C.L.I. Fall Program Offers Four Courses

The Fall quarter program of the Chicago Lighting Institute has opened, offering four courses, co-sponsored by the Chicago Section, I.E.S. and the Illinois Institute of Technology.

"Basic Principles in Lighting Sales" comprises twelve two-hour classes held once a week from October 2 through December 18. Ralph Hazlett, President of the Executive Institute in Chicago, has been engaged as lecturer and discussion leader for these sessions. Tuition for the entire course is $20.00.

The two-part — lecture and laboratory — course in "Lighting Fundamentals" is again being presented under Robert Ligare as instructor in the twelve lecture classes and William D. Richards in the six laboratory sessions. Lectures are weekly from October 6 through December 22; laboratory periods are biweekly from October 8 through December 17. The tuition fee of $20.00 covers both parts.

Frank R. McShane is instructor for the twelve classes on "Wiring Design Number 1," which are held October 7 through December 23. This course is prerequisite to "Wiring Design 2A" which will be given during the winter quarter. Tuition for these weekly classes is $20.00.

Ten sessions on "Residential Lighting" are being held, October 15 through December 17, with Kerr Sanders as instructor.

These courses are all held at the Chicago Lighting Institute, 37 S. Wabash Avenue, Chicago. Additional information can be obtained from Carl W. Zersen, Managing Director of the Institute.

In cooperation with the Chicago Area Camera Clubs Association and the Associated Amateur Cinema Clubs, the Institute is sponsoring a week of lectures and demonstrations on the "Application of Artificial Light in Amateur Photography." Monday, November 3 through Friday, November 7 is the week. Admission is free. Further details are available from C.L.I.

LIGHTING CALENDAR

Society Events

December 11, 1952—Meeting of I.E.S. Council, New York, N. Y.

February 12, 1953—Meeting of I.E.S. Council, New York, N. Y.

March 23-24, 1953—Canadian Regional Conference, Chateau Laurier, Ottawa, Ont.

April 12-14, 1953 — Southwestern Regional Conference, Hotel Baker, Dallas, Texas.

April 23-24, 1953—Pacific Northwest Regional Conference, Multnomah Hotel, Portland, Ore.

April 30 - May 1, 1953 — Midwestern Regional Conference, Hotel Radisson, Minneapolis, Minn.

May 14-15, 1953 — East Central Regional Conference, Hotel Lord Baltimore, Baltimore, Md.

May 18-19, 1953 — Southern Regional Conference, Sedgefield Inn, Greensboro, N. C.

May 25-26, 1953 — Great Lakes Regional Conference, Syracuse Hotel, Syracuse, N. Y.

September 14-18, 1953 — Illuminating Engineering Society, National Technical Conference, Commodore Hotel, New York, N. Y.

Industry Events

November 10-13, 1952 — National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

November 17-19, 1952 — 39th National Foreign Trade Convention, Waldorf-Astoria Hotel, New York, N. Y.

November 19, 1952 — 34th Annual Meeting, American Standards Association, Waldorf-Astoria Hotel, New York, N. Y.

November 30 - December 5, 1952 — Annual Meeting, The American Society of Mechanical Engineers, Statler Hotel, New York, N. Y.

January 19-22, 1953 — Plant Maintenance Show, Public Auditorium, Cleveland, Ohio.

January 19-23, 1953 — Winter General Meeting, American Institute of Electrical Engineers, New York, N. Y.

January 26-29, 1953—American Society of Heating and Ventilating Engineers, 59th Annual Meeting, Conrad Hilton Hotel, Chicago, Ill.

March 9-13, 1953 — National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

March 30 - April 3, 1953 — Annual Sales Conference, Edison Electric Institute, Edgewater Beach Hotel, Chicago, Ill.

May 24-28, 1953 — National Association of Electrical Distributors, 45th Annual Convention, Conrad Hilton Hotel, Chicago, Ill.

Week of May 24, 1953 — 45th Annual Convention, National Association of Electrical Distributors, Chicago, Ill.

June 1-4, 1953 — 21st Annual Convention, Edison Electric Institute, Atlantic City, N. J.

June 28 - July 3, 1953 — American Society of Mechanical Engineers, Semi-Annual Meeting, Statler Hotel, Los Angeles, Calif.

June 29 - July 3, 1953 — Summer General Meeting, American Institute of Electrical Engineers, Atlantic City, N. J.

August 18-21, 1953 — Pacific General Meeting, American Institute of Electrical Engineers, Vancouver, B. C.

September 21-26, 1953 — 25th Jubilee Meeting, International Association of Electrical Inspectors, Edgewater Beach Hotel, Chicago, Ill.

September 23-25, 1953 — Annual Meeting, Canadian Electrical Manufacturers Association, General Brock Hotel, Niagara Falls, Ont.

October 19-23, 1953 — 41st National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

November 9-12, 1953 — National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

January 18-22, 1954 — Winter General Meeting, American Institute of Electrical Engineers, New York, N. Y.

March 8-11, 1954 — National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

SOME of the visitors to the Corning Glass Center getting together for informal discussions are (in the photo at left) C. R. Seybold, C.A.A.; Marcus Gilbert, C.A.A.; Frank Breckenridge, National Bureau of Standards; Dick Madigan, Line Material Co.; H. R. Blackwell, University of Michigan; (Photo at right) Paul Pevot, Corning Glass Works; Al Clarke, Crouse-Hinds Co.; John Hoxie, Corning Glass Works, Bob Blatt, *Electrical World*; Al Morse, C.A.A.; Lew Moore, Grimes Mfg. Co.; C. A. Douglas, National Bureau of Standards; A. I. Dahl, National Bureau of Standards; Stuart Rich, Glowmeter Corp.

Two-Day Aviation Conference Meets at Corning Glass Center

Top men in the aviation field, some 75 strong, traveled from all parts of the country last month, to attend the Aviation Lighting Conference held in Corning, N. Y., October 2 and 3. The conference was sponsored by the I.E.S. Committee on Aviation Lighting, R. B. Blatt (*Electrical World*), Chairman. Host for the meeting was the Corning Glass Works, who with John P. Hoxie and D. L. Killigrew as co-ordinators, turned over the facilities of the Glass Center to the aviation group.

The meeting was a full-scale aviation lighting convention, complete with a ladies program and especially valuable technical sessions of some eleven papers.

In addition to the planned aviation lighting program, an extra dividend was afforded delegates and guests in a joint dinner meeting, October 2, with the Central New York Section of I.E.S., at the Baron Steuben Hotel, Corning. Some 125 members and guests attended this affair. Master of Ceremonies for this dinner meeting was Warren H. Lawrence, Chairman of the Central New York Section.

"Mystery" speaker (unscheduled) at the dinner was Lew Moore, past-chairman of the Aviation Lighting Committee, who presented a gag speech, pseudo-scientific, which Fred Allen should have caught (if he ever wants to make good on TV). Straight-face delivery, but his was the only straight face in the crowd.

Speaker of the evening, however, was Dr. E. U. Condon, Director of Research at Corning Glass Works, who spoke on the "Nature of Light." Dr. Condon was introduced by D. L. Killigrew, Corning Glass Works.

I.E.S. President E. M. Strong, one of Central New York Section's own members, was guest of honor at the dinner meeting. An additional highlight to his presence was the ceremony, presenting him with a certificate of Fellow status of I.E.S. Presentation was made by Dr. H. P. Gage, Member Emeritus of the Central New York Section. Professor Strong addressed the group, acknowledging his special pleasure in receiving this honor from the hands of Dr. Gage.

Some 25 ladies attending the Conference enjoyed a planned program under the direction of Mrs. John P. Hoxie. A downpour failed to dampen the enthusiasm, in a tour, Thursday morning, of Watkins Glen, a scenic wonder about 20 miles from Corning. After luncheon at the Jefferson Hotel, the group joined the men in a tour of the Corning Glass Center and a lecture demonstration by Dr. W. W. Shaver on "New Advances in Technical Glass."

AVIATION Lighting Committee visits Corning Glass Works to see craftsmen make lovely Steuben glassware.

FELLOW Certificate is presented to E. M. Strong by Dr. H. P. Gage, at the meeting of the Central New York Section October 2.

Papers presented during the technical sessions included:

OCTOBER 2, MORNING SESSION

Ideal Beam Pattern for Runway Marker Lights—M. S. Gilbert, C.A.A.'s Technical Development and Evaluation Center.

The Kinorama as an Evaluator in Aviation Lighting—F. C. Breckenridge, National Bureau of Standards.

Fog Dispersal by Radiant Tubes—Dr. E. F. Flock and A. I. Dahl, National Bureau of Standards.

Airport Lighting Maintenance Problems and Solutions — R. E. Madigan, Line Material Co., and C. R. Seybold, C.A.A. Region 3.

OCTOBER 2, AFTERNOON

Recent Researches in Visual Detection with Reference to Aviation Lighting—H. Richard Blackwell, Vision Research Laboratory, University of Michigan.

Airport Apron and Ramp Lighting — H. N. McIntyre, General Electric Co., Lighting Division.

Lecture Demonstration on New Advances in Technical Glass — W. W. Shaver, Corning Glass Works.

History of Glass — Paul Perot, Corning Glass Works.

Dinner at Baron Steuben Hotel, Joint Meeting with the Central New York Section, and evening program feature on The Nature of Light by E. U. Condon.

OCTOBER 3

Relation between Reported Visibility and Pilot Visibility from Aircraft — C. A. Douglas, National Bureau of Standards.

Aircraft Lighting and Collision Avoidance — A. L. Morse, C.A.A. Technical Development and Evaluation Center.

Glowmeter Instrument Lighting System — Stuart Rich, Glowmeter Corp.

Latest Reports on Aircraft Lighting Practice —organized by W. C. Fisher, Navy Bureau of Aeronautics and Ken Dean, General Electric Co., Lamp Division.

Subway Lighting Survey Puts I.E.S. in Limelight

The Illuminating Engineering Society hit the front page recently when its recommendations for transportation lighting were cited by the *New York World-Telegram*, in its report on the lighting in New York City's subway system. Likewise, the recommendations for "safe assembly or movement of people" were used in evaluating the illumination levels on station platforms, mezzanines, stairways and rest rooms. In few cases did the newspaper find that the lighting in the underground transit system was up to the minimums specified by the Society.

JOINT dinner meeting was held at the Baron Steuben Hotel by the Central New York Section and the Aviation Lighting Committee.

Fall Lighting Conference Presented by Cornhusker Chapter

A program, featuring practical applications of lighting and related problems and solutions drew a fine response at the Fall Lighting Conference given by the Cornhusker Chapter of I.E.S. Held in Omaha, September 26, the conference began with registration in the morning. After a luncheon, Chapter Chairman E. E. Schwalm presided. Attendance was about 50.

First speaker was R. F. Townsend, of Westinghouse Electric Corp., whose topic was "The Latest in Lighting Sources and Circuits." He was followed by Guy Jones, of the General Electric Co., who spoke on "See Your House in a New Light—Bright Future."

A seminar, "One of My Most Interesting Lighting Jobs," was under the chairmanship of Emory Pardun, Iowa Public Service Co. A roundtable discussion period featuring lighting questions and answers, with George Mittauer of George C. Mittauer & Associates, as Moderator, ended the afternoon meeting.

A social hour, courtesy of the Entertainment Committee, was held in the Emblem Room of the Rome Hotel, where the Conference took place, and a smorgasbord dinner satisfactorily ended the proceedings.

University of Wisconsin Sponsors Illumination Institute

The University Extension Division and the College of Engineering of the University of Wisconsin have conducted, October 28-30, the first of probably annual programs constituting an Illumination Institute. Purpose of the institute is "to enable builders, architects, consulting engineers, electrical contractors, school and municipal officials and utility employees to become familiar with the increasing importance of proper illumination and lighting techniques."

The three-day program began with a welcome by Professor L. C. Larson of the Electrical Engineering Department. The first day's program continued with:

An Architect's Approach to Lighting — Roger C. Kirchhoff, Wisconsin State Architect.

Tour of Illumination and Photometry Laboratory, with Professor Larson.

Color Conditioning (a film) — Du Pont Company.

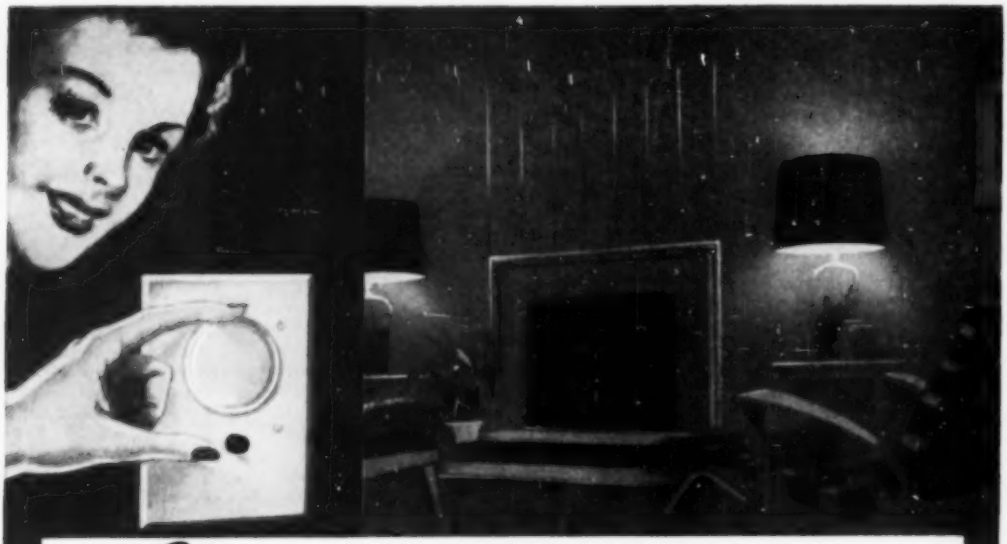
Engineered Lighting with Prismatic Lenses — Edward H. Grieb, Holophane Company, Inc., Wauwatosa.

Lamp Sources of Illumination—Ben F. Avery, General Electric Co., Milwaukee.

A Bright Future (a film) — General Electric Co.

At the dinner meeting the opening

(*Continued on page 11A*)



Now A NEW CONCEPT IN LIGHT CONTROL

the Wallbox Dimmer FOR MOUNTING INTO A WALL

- *SMOOTH, STEPLESS DIMMING FROM FULL-ON TO BLACKOUT*
- *USE IN PLACE OF REGULAR ON-OFF SWITCHES*
- *WALL PLATES TO MATCH ANY ROOM DECOR*
- *CONTROLS LIGHTING LOADS UP TO 360 WATTS*
- *APPROVED BY UNDERWRITERS' LABORATORIES*

The new Superior Electric WALLBOX DIMMER is a continuously adjustable transformer to dim and brighten lights. Cool and efficient in operation it does not dissipate power in the wasteful form of heat like a resistance type control. Any number of lamps up to the full rated capacity of 360 watts may be used, and it does not have to be tailored to the load. A fuse is provided to protect the unit, and a bi-metallic thermal overload relay gives overall circuit protection.

Send today for complete information. Learn how the new WALLBOX DIMMER can give you truly effective light control. Just write to:

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THE SUPERIOR ELECTRIC CO.
BRISTOL, CONNECTICUT

Easy to Install

As an ordinary wall switch - -

Mount box in wall opening . . . fits standard 2 x 4 wall construction.

Pull in wire (through bottom or sides).

Mount the dimmer unit in the box, secure with four screws.

Finish the job by attaching wall plate and control knob.

YOU CAN USE THIS PRODUCT

IN THE HOME

— living, dining and recreation rooms to dim or brighten light intensity to suit activity. Dim down for night light.

IN CHURCHES

— helping to create an atmosphere of dignity and reverence at the altar or in the chapel.

RESTAURANTS, COCKTAIL LOUNGES, HOTELS

— properly controlled lighting to enhance the enjoyment of food and entertainment.

THEATRES, LODGES, SCHOOLS, SMALL AUDITORIUMS

— for dimming house lights. Controlled illumination in corridors, stairways, etc.

— AND FOR HUNDREDS OF OTHER APPLICATIONS

- STABILINE AUTOMATIC VOLTAGE REGULATORS
- POWERSTAT VARIABLE TRANSFORMERS
- VARICELL D-C POWER SUPPLIES
- VOLTBOX A-C POWER SUPPLIES
- SUPERIOR 5-WAY BINDING POSTS
- POWERSTAT LIGHT DIMMING EQUIPMENT

(Continued from page 9A)

day, the featured speaker was Midwestern Regional V-P Charles N. Laupp, who addressed the Institute on "Dividends Through I.E.S." He made use of the display panel which the Milwaukee Section had made for regular Section meetings, showing the various publications which are available from the Society.

The second day of the Illumination Institute had the following program:

Aspects of Commercial and Industrial Lighting Design and Costs — John D. Bland, Sylvania Electric Products, Inc., Minneapolis.

Street Lighting — Clarence W. Puent, Line Material Co., Milwaukee.

Utilization of Lamp Colors—Charles N. Clark, General Electric Co., Cleveland.

Application of Glassware in Lighting — Clarence W. Clarkson, Corning Glass Works, Chicago.

Color Dynamics Applied to Lighting Design — J. C. Thompson, Pittsburgh Plate Glass Co., Milwaukee.

On October 30, the third and final day, these four addresses were made to the enrollees:

Coordination of Illumination and Acoustics — George Gilleard, Curtis Lighting, Inc., Chicago.

Floodlighting of Buildings for Architectural Appreciation and Protection — Merle E. Keck, Westinghouse Electric Corp., Cleveland.

Illumination Design and Balancing the Account for Lighting — Leonard V. James, Illuminating Engineering Consultant, La Grange, Ill.

Certificates were presented to those who attended the sessions. Tuition for the course was $20.00. All sessions were held in the new Engineering Building at the University.

St. Louis Section, I.E.S. Outlines Year's Program

A printed booklet has been issued to all members of the St. Louis Section, outlining the Section's monthly programs for the entire year. Most of their meetings are scheduled as dinner meetings — a device which, in this Section at least, has resulted in good attendance.

The kick-off meeting, held September 18, started the year right with an attendance of 103. L. M. Wallace, Jr., chairman of the Section, introduced the other new officers and committee chairmen.

S. G. Hibben, retiring President, was the featured speaker and delivered an interesting discussion, reviewing the National Technical Conference in Chicago, and also giving a thorough background on the many contributions that the Society has made to industry, to mankind, and to the citizens of this country.

The second meeting of the year, held October 23, featured Mr. J. W. McAfee, President of the Union Electric Co. of Missouri, who spoke on "St. Louis — Tomorrow's Capital of Industry and Lighting."

The program planned for the rest of the year and the speakers are as follows:

November 13, 1952 — "The I.E.S.—What It Stands For—What It Is Doing—Its Future," C. C. Keller, Holophane Co., Inc., and General Secretary, I.E.S. Mr. Keller will also discuss "Lens Lighting."

December 11, 1952 — Panel discussion on "Lighting for St. Louis." M. E. Skinner, Union Electric Co. of Missouri, Moderator. "The Emotional and Religious Aspects of Lighting at Christmas Time," Joseph Taylor.

January 15, 1953 — "Commercial Lighting," D. P. Caverly, Sylvania Electric Products, Inc.

February 19, 1953 — "Industrial Lighting," Merle E. Keck, Westinghouse Electric Corp.

March 19, 1953—"Residential Lighting," Kaye Leighton, General Electric Co.

April 23, 1953—Under direction of the Study Club of the Section, St. Louis area lighting installations will be illustrated and reports made by 10 successful entrants with a cash prize award for the winner.

May 1953 — Annual Dinner Dance.

In addition to the dinner dance, a special feature on the agenda is a joint meeting, February 12, with the American Society of Safety Engineers. Subject for this meeting is "Poor Lighting — The Cause of Many Accidents."

Advanced Lighting Applications Course Sponsored by Capital Section

In cooperation with the Electric Institute of Washington, the Capital Section, I.E.S., held a full day, 10 a.m. to 9 p.m., course, October 1, on the applications of lighting and materials employed. A breakdown of the attendance of 102 indicates the widespread interest aroused:

Architects and consulting engineers	20
School and store engineers	8
Jobber salesmen	24
Manufacturer's representatives	22
Contractors	16
Utility personnel	12

More than a refresher course, the program was planned to cover subjects of particular interest to lighting men in the Washington area. Topics and speakers were:

Trends in Lighting Practice — R. G. Slauer, Sylvania Electric Products, Inc.

Acrylic Plastics for Illumination — H. A. Williams, Rohm & Haas.

Light for Selling—Stores — R. Dorsey, General Electric Co.

Architectural Lighting — Edward Rambusch, Rambusch Decorating Co.

Light for Seeing—Schools, Offices — John Neidhart, Westinghouse Electric Corp.

The Open Forum following dinner was a popular and educational feature to round off the symposium.

Held in the Electric Playhouse, PEPCo. Bldg., this concentrated dose of what's new in lighting application cost only $6.00, including lunch and dinner.

NAUTICAL note is evident at the opening meeting of the Fall Lighting Campaign, conducted under the auspices of the Electrical Association of Philadelphia. Approximately 250 people from many phases of the electrical industry attended.

"Flying Saucers" Produced In Laboratory Demonstration

An electrical discharge phenomenon produced in a vacuum bell jar at the Engineer Research and Development Laboratories, Fort Belvoir, Va., is advanced as a possible solution to the mystery of "flying saucers," by Noel W. Scott, physicist.

Working with a vacuum bell jar on experiments in mirror and lens coating,

(Continued on page 12A)

"FLYING SAUCER" — laboratory model — begins to form in vacuum bell jar under the scrutiny and direction of physicist Noel W. Scott of Engineer Research and Development Laboratories, Fort Belvoir.

(*Continued from page* 11A)

Mr. Scott produced an eerie orange object that bears a striking similarity to the "flying saucers" that many claim to have seen.

To produce the "saucers" and make them behave in a likely fashion, air is pumped out of the bell jar to create a partial vacuum. The air left in the jar is electrified by discharge between highly charged electrodes. Air is then introduced from the outside, causing a relatively bright glow to form on some portions of the positive electrode. By varying the amount of air introduced into the jar, the color of the "saucers" varies from orange-red to purple, pink to white. Introduction of helium into the chamber produces a green "saucer."

Mr. Scott produced "saucers" in many of the shapes that have been sighted to date. A wave of a magnet outside the jar and the laboratory-made "saucers" skirted elusively about the rim of the jar, stood still, reversed their fields and in general behaved very much like those reported. "The saucers," Mr. Scott states, "remain stationary, move at an excessive rate of speed or change direction almost instantly by altering the direction and intensity of the rays and the electric and magnetic fields, and by changing the atmospheric pressure. Scott does not offer this explanation as the only answer to the mystery. "It is just one theory," he says, "and not even a new one at that." He repeatedly states, "The atmospheric conditions necessary for producing this phenomenon are not the *prevailing* conditions that exist in the upper atmosphere. However, it is not altogether improbable that there may be *occasional* local conditions responsible for this glow which might be interpreted as flying saucers."

I.E.S. National Technical Conferences

1954 — Atlantic City, N. J.
1955 — Cleveland, Ohio
1956 — Boston, Mass.
1957 — Atlanta, Ga.
1958 — Toronto, Ont.

Residence Lighting Forum Active in Tennessee Valley

Looking ahead to an active year in 1952-1953 the Residence Lighting Forum, sponsored by the Tennessee Valley Section, adopted by laws and elected officers at an organizational meeting last April. At this meeting there were 26 members and 4 guests present. The officers and committees elected are:

Chairman—May Love Gale
Secretary—Margaret Putnam
Treasurer—Evelyn Herron
Members at Large—Clyde Carpenter, Bert Osborne, Bill Schoenherr
Program Committee—Leah Parker, Chairman; Ellen Monroe; Frances Hutchison; W. E. Schoenherr
Membership Committee—John Gilchrist, Chairman; Inez Lovelace; Bill Morrison; Maribel M. Burch.

Since there are four large cities represented by the membership, the Forum will rotate its meetings, holding one in each of the four cities. The first program meeting of the year was held October 7.

Street Lighting Committee Tours Chicago

While in Chicago for the National Technical Conference, about 30 members of the Committee on Street and Highway Lighting took the opportunity to examine the new street lighting in Chicago and Park District. With F. D. Wyatt and Lloyd Johnson in charge, dinner was held at the Normandy House, and then all evening until after eleven o'clock, the Committee members toured the city in a chartered bus.

Photo Credit Omitted

The Chicago Conference Committee points out that photo-credit in the convention story published in October I.E. is also due J. Richard "Dick" Wessling, Vice-President of Electric Supply Corp., Chicago. Mr. Wessling took over 80 excellent pictures, as one of the conscientious members of the Attendance and Publicity Sub-Committee.

IT SEEMS TO ME

Illumination Courses in U. S. and Canadian Colleges

The results of this survey[1] merely confirmed what most educators interested in illumination already knew: First, that illumination was being dropped as a required course from most Electrical Engineering curricula. Second, that in many cases, it was being dropped entirely instead of becoming an elective course or appearing in a power option sequence. It seems that this trend will continue.

The question before us is what can be done about this rather disturbing tendency, in view of the many new developments in the field.

First let us try to review some of the reasons for the present unpopularity of illumination courses.

(1) New developments in Electrical Engineering accelerated by the war have been clamoring for place in the Curriculum. Illumination courses are one of the casualties of this pressure. The integration of these new developments has been further hastened by offers of positions in these new fields at *top salaries*. Beginning salaries in Illumination do not match these. Further, men now being appointed to Electrical Engineering departments usually have backgrounds in these newer fields. I fully agree with Professor Timoshenko[2] that the "— majority of its faculty is not sufficiently familiar with the subject to enjoy teaching it."

(*Continued on page* 14A)

NEW lead-lag slimline ballast

SLASHES COSTS... SLASHES MAINTENANCE

An *exclusive,* new design for slimline *lead-lag* ballasts slashes prices, sizes, and weights to series ballast levels . . . yet provides lead-lag dependability. This means long-range economy for your customers. Longer lamp life . . . full-rated lamp life . . . no more guesswork about lamp burnouts. A real savings in maintenance time and money. Get the full story on the new Westinghouse *lead-lag* ballast. Send for B-5614, Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-04317

YOU CAN BE SURE...IF IT'S
Westinghouse

LIGHTING DIVISION
Edgewater Park, Cleveland, Ohio

(Continued from page 12A)

(2) Most textbooks are not very technical and few if any go properly into basic concepts and definitions. In many cases they go into design in cook book fashion, giving a procedure without the necessary theory, background and development. The weakness in the textbooks is transmitted to both students and instructors, who often regard Illumination as a "snap" course. This recipe method is further aggravated by over-simplified manufacturer's data aimed at laymen rather than engineers. Witness the reason given for using room index as a letter rather than a number; namely that the room index might be used for the coefficient of utilization.

(3) The tendency for many firms concerned with lighting is to hire salesmen and use them as application engineers. In a survey on job opportunities in Illumination by my students, one utility replied "illumination is not an engineering function."

(4) Lack of active recruiting of young engineers by utilities. This fact has been commented editorially by the magazine *Electrical World*.

Now as to what can be done about this situation.

(1) The I.E.S. Committee on Lighting Education should review all power options in Electrical Engineering and see if anything can be done about keeping Illumination courses in such options.

Illumination having been pushed out the front door by developments such as television is coming back through the back door by development of color television. The photometric and colormetric foundation of television has been virtually ignored by the Illuminating Engineering Society (at least insofar as technical papers are concerned). The basic articles on sources, levels required, etc. on the subject have appeared elsewhere (occasionally with incorrect use of terms). Television engineers are developing their own terms and usage.

(2) Textbooks should be up to date with a clear development of basic terms and should include such material as interreflections, colorimetry, perhaps some material on photometry in chemical analysis, and basic circuitry of gaseous discharge sources. Perhaps some of these developments are too new. However, they are necessary to proper understanding. A series of articles on fundamentals of the field in ILLUMINATING ENGINEERING might be in order.

An educational campaign is necessary to convince schools of architecture to include illumination courses. This course should give the architect a good basic and technical grasp of the subject. I am deeply disturbed by Prof. Timoshenko's statement[2] that it would be useless to teach a course in fundamentals to architects. Illumination actually comes to the Electrical Engineering group by default. The modern concept of illumination is that it is a part of our environment. Control of this environment is distinctly a function of the architect. Let the engineer concentrate on circuitry and improvement of light sources, while the architect uses these sources to give us an integrated pleasing environment, free from glare and harsh shadows, with sufficient illumination. It would seem that because the engineer designs the wiring, he must also specify the lighting unit and in some cases design it. This is carried to the absurdity where electricians not only install but *design* the lighting system. The latter is far from uncommon.

(3) An even stronger educational campaign must be carried on to convince many firms, that with the newer light sources, careful design is essential, and that merely installing footcandles and fixtures will only lead to disaster.

In conclusion, I agree with Prof. Timoshenko that Illuminating Engineering Courses are disappearing despite tremendous advances in the field and in applications to other fields. These new developments must be presented in such a fashion, that the colleges will agree that this is a course worth using precious curricula time, and that illumination is not just something that can be learned by picking up a manufacturers' catalog.
—A. ABRAMOWITZ, *Assistant Professor in Electrical Engineering, City College of New York.*

1. "A Survey of U. S. and Canadian Colleges Offering Illumination Courses." ILLUMINATING ENGINEERING, Vol. XLVII, No. 8 (August 1952), page 425.
2. Timoshenko, G. S.: "Basic Education in Illuminating Engineering," ILLUMINATING ENGINEERING, Vol. XLVII, No. 6 (June 1952), page 295.

ABOUT PEOPLE

R. L. Biesele, Jr., has been appointed Engineering Vice-President of the Toff Corporation, Dallas, Tex. In this new position, he is directing a development program on photoelectric instrumentation. Mr. Biesele was formerly Chairman of the Department of Electrical Engineering and Research Professor of Engineering at Southern Methodist University.

C. C. Shotwell has been appointed Assistant Manager of Market Studies and Service Division of Philadelphia Electric Co. Mr. Shotwell was formerly Supervisor of Lighting Applications for the company.

Dr. A. F. Dickerson, recently retired manager of General Electric Company's Lighting and Rectifier Department, addressed the annual conference of the British Association of Public Lighting Engineers, September 17 at Harrogate, England. Dr. Dickerson discussed the subject, "Street Lighting — U.S.A.," before a group of delegates appointed by local authorities, and Electricity and Gas Boards throughout the British Isles. Dr. Dickerson, who retired just prior to this trip, after 42 years with General Electric, will remain as consultant with his former department in that company.

Ralph C. Stuart and **Robert D. McManigal**, Westinghouse Electric Corp. executives, have returned from a six-week tour of Europe, investigating post-war developments in the lamp industry and the lighting field abroad. The inspection itinerary included France, England, The Netherlands, Germany, Switzerland and Belgium.

The appointment has been announced of **Reynold S. Smith, Jr.** to the newly-created post of Assistant to the President of Unistrut Products Co., Chicago. Mr. Smith is co-author of a recent book, "Job Evaluation."

William J. Fleming has been appointed general manager of General Electric Co.'s Lighting and Rectifier Department in Schenectady, succeeding Dr. A. F. Dickerson.

Appointments of **Kenneth D. Scott** as assistant manager of General Electric's Glass Machine Works at Cleveland, and **E. A. Whitmore** as manager of the Kentucky Glass Works at Lexington, Ky., have been announced. Mr. Scott has been manager of the Kentucky Glass Works since it began operations six years ago. Mr. Whitmore has been assistant to the manager of the plant for the same period.

H. C. Dean, Vice-President of Consolidated Edison Co. of New York, has been awarded a certificate of service by the American Standards Association in recognition of his work in the development of American Standards. Mr. Dean is a member of the A.S.A. Standards Council, representing the Electric Light and Power Group.

(Continued on page 17A)

Smithcraft AREA ILLUMINATION-

CHALLENGE

TO THE LIGHTING INDUSTRY

A challenge to create new and striking lighting effects . . . a challenge to increase lighting levels materially with accompanying comfort . . . a challenge to use Smithcraft Area Illumination to implement your own lighting ideas.

Smithcraft Area Illumination brings to overall lighting a brand new structural simplicity that eliminates previous mechanical difficulties of installation and servicing. This system is actually one lighting "fixture" of limitless dimensions. There is no multiplicity of supports to the ceiling or complicated electrical service connections to clutter the plenum and interfere with other services.

With Smithcraft Area Illumination, the architect and engineer have an unrestricted freedom of choice as to size, pattern, shielding, intensity and periphery . . . and it's economical efficient extremely easy to install.

After thorough investigation of all available overall lighting, Smithcraft Area Illumination has been chosen by America's leading companies for today and tomorrow's finest lighting installations.

freedom of SIZE
freedom of PATTERN
freedom of INTENSITY
freedom of SHIELDING
freedom of PERIPHERY

Write for further information on Smithcraft Area Illumination

Smithcraft
LIGHTING DIVISION
CHELSEA 50, MASSACHUSETTS

MOBILEX

A NEW IDEA IN LIGHTING

BY DAY-BRITE

MOBILEX introduces a new, flexible recessed lighting system designed for use as an integral part of the newly developed grid-type suspended ceiling which consists of interlocking "tees" supporting Fiberglas* Ceiling Boards.

MOBILEX is available in 2′ x 2′ units for two, three or four 20-watt fluorescent lamps and in 2′ x 4′ units for two, three or four 40-watt fluorescent lamps. RAPID-SMOOTH START ballasts are standard on all 40-watt units.

Three shielding elements provide a variety of pleasing patterns. Moulded plastic (illustrated above), Skytex glass, and Boxco (R) louvered frames are interchangeable and hinge from either side for easy servicing.

MOBILEX is extremely flexible. Units may be used singly, end to end, or side by side . . . and in any combination. A wealth of interesting patterns is possible.

Installation is simple. Compress the sides of the fixture to clear ceiling rails. Insert the fixture into the grid opening and let it rest on the rails. End baffles lock the compression feature in place. Make electrical connections, add hinged shielding frame and installation is complete.

MOBILEX is new, practical and competitively priced. Here's a perfect answer for those tough remodeling jobs and new projects with a limited budget. Get the full MOBILEX story. Write for Bulletin OD-567—today.

*Fiberglas is the trade mark (Reg. U. S. Pat. Off.) of Owens-Corning Fiberglas Corp., Toledo, Ohio

ABOVE: Easy to install. Simply compress the sides of the fixture and insert it into the grid opening.

BELOW: No hangers or suspension straps. Fixture rests on grid rails. Fixtures can be added or changed at any time.

"DECIDEDLY BETTER"
DAY-BRITE
Lighting Fixtures

277

Day-Brite Lighting, Inc., 5432 Bulwer Ave., St. Louis 7, Missouri
In Canada: Amalgamated Electric Corp., Ltd., Toronto 6, Ontario

(Continued from page 14A)

The appointment of **Lew D. Tuck** as sales manager for the lighting division of the Cutler Light Manufacturing Co. was announced recently. Mr. Tuck comes to this company from Jewel Products, Inc., Bloomfield.

The American Society for Testing Materials has announced the election of **Robert J. Painter** as Executive Secretary and of **Raymond E. Hess** as Associate Executive Secretary and Editor in Chief. This action was taken by the Board of Directors following the report of a special committee which had been appointed to recommend a successor to the late C. L. Warwick.

Acme Electric Corp., Cuba, N. Y., has announced the organization of Acme Electric International, Inc., a subsidiary to handle western hemisphere export sales. Officers of the new corporation are **W. E. Wilson**, president; **J. A. Comstock**, vice-president; **Phil Arnold**, secretary and controller and **C. J. Anderson**, treasurer. Headquarters will be located in Cuba, N. Y.

Donald E. Jenkins has been appointed plant manager of the Westinghouse Electric Corp.'s new Vicksburg, Miss., Lighting Division plant. **Thomas G. Cameron** has been named superintendent of manufacturing. The new plant will be devoted entirely to manufacture of lighting units.

Max D. Gruber, 235 W. 58th St., New York, N. Y., has been appointed representative for Lithonia Lighting Products Co. and for the J. A. Wilson Lighting and Display Inc.

Frank L. Lewis has been appointed to the newly-created post of Regional Sales Manager for the Central Region of the Illuminating Division of the Miller Company, Meriden, Conn. Mr. Lewis was formerly field sales engineer in the Central Ohio Territory for that company.

David B. Bluford has been appointed vice-president in charge of sales for Luminous Ceilings, Inc., Chicago. Mr. Bluford was formerly with United Air Lines.

B. F. Greene, of B. F. Greene, Consulting Engineers, has been named Chairman of the Illuminating Division of the New York Section of the American Institute of Electrical Engineers for the year 1952-1953.

Leader Electric Co. has appointed **Mel Knox** as their direct factory representative for the Washington, D. C. area. His offices will be at 229 Bond Bldg., Washington.

OBITUARIES

William T. Blackwell, Member Emeritus of the Illuminating Engineering Society, died recently after a long illness. Mr. Blackwell joined the Society in its first year, 1906. Later, as an active member of the old Northern New Jersey Chapter and then the New York Section Mr. Blackwell served the Society on various committees, including the Committee on Street Lighting, the Committee on Industrial and School Lighting and the Sustaining Membership Committee. In 1946, he retired after 24 years with the Public Service Corporation of New Jersey, and in 1947 was elected to the grade of Member Emeritus of I.E.S. He was also a member of the American Institute of Electrical Engineers and was active on the Newark Safety Council.

Leonard T. Blaisdell, long-time member of the Illuminating Engineering Society, died recently of a heart attack at his home in Dallas, Texas. Mr. Blaisdell first joined the Society in 1925, as a member of the Southwestern Section. He was affiliated with the General Electric Compaay throughout his career, from 1904 to 1949, when he retired. During part of this era he resided in Cleveland, where he was an active member of the Cleveland Section. On his retirement he returned to Dallas.

BOOKS AND PAMPHLETS

Books whose reviews are marked • are available for inspection at Headquarters Office, Technical Dept.

•**The Technique of Stage Lighting** by Rollo Gillespie Williams, published by Pitman Publishing Corporation, New York, revised 1952; 210 5¼ x 8½ inch pages, 79 illustrations; price $6.00.

This revision contains new developments in lamp engineering and theatrical lighting control devices since the first publication of the book in 1947. The volume deals predominantly with theatrical practice in Great Britain, the author explaining in his Preface, "In America the main difference is that higher lighting intensities are often employed, and spotlights are used to a greater extent for building up the general lighting." In addition to those connected with the theater, the book should be of interest to people concerned with display.

The text is divided into four parts. Scientific Basis (vision and color, and control and measurement of illumination); Adaptation and Control of Light (light sources and color filters, stage lighting apparatus, dimmers and lighting control equipment, stage lay-out and design, planning the stage lighting for professional, private and motion picture stages); The Art of Stage Lighting; and Practical Lighting for Stage Productions (suggestions for lighting plays, opera, musical shows, revues, ballet and motion picture curtain effects).

•**Ultraviolet Radiation** by Lewis R. Koeler, published by John Wiley & Sons, Inc., New York, 1952; 279 5½ x 9 inch pages, 148 illustrations, 77 tables; $6.50.

This book was prepared for professional and technical people who sometimes deal with ultraviolet energy. The author did not intend it to cover the entire field comprehensively but rather "to answer some of the questions which confront physicists and specialists in fields other than physics when they find it necessary to work in this portion of the spectrum."

After an introductory section defining ultraviolet terminology and units the author deals at length with arc sources of ultraviolet energy and then more briefly with incandescent sources and solar radiation, giving considerable data on the performance of present-day lamps and on measurements of ultraviolet in daylight. The following chapters deal with u-v transmission and reflection characteristics of a wide range of materials, applications and effects of u-v, and u-v measuring and detecting devices. "Applications and effects" include brief discussions of erythema, pigmentation (tanning), conjunctivitis, ricket prevention and cure, vitamin D, germicidal effects and those on other small organisms, product sterilization, disinfection of air and liquids, ozone, fluorescent lamps, fluorescent black-light and sun lamps.

•**Electrical Drafting and Design** by Calvin C. Bishop, Third Edition published by McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York 18, N. Y., 1952; 280 6 x 9 inch pages, 138 illustrations, 90 tables; price $4.50.

This book is intended as a textbook for those planning to enter the field of electrical design beginning as draftsmen. It is a practical book with problems arranged to give practice in applying tables, formulas and charts found in power and lighting handbooks and manufacturers' tables. This revision is based on the 1951 revision of the National Electrical Code.

(Continued on page 18A)

(Continued from page 17A)

The 18 page chapter on lighting represents an attempt to reduce lighting design to a very elementary level, design based solely on quantity of illumination with no mention of quality. Although the 23 pages of related appendix are reproduced for the most part directly from the Second Edition of the *I.E.S. Lighting Handbook*, the text gives the room index equation which appeared in the First Edition (replaced in the Second Edition by functional equations which more nearly approximate experimental data). After dealing with how to approximate the number, size and location of luminaires, the author explains wiring layout for the lighting system.

Other topics treated include general instructions for mechanical and electrical drafting, circuit diagrams, switchboards for d-c generators and 2300-volt service, outdoor substations, and wiring layout for power and lighting in residences, offices and industrial plants. Over one hundred pages of related tabular data is appended.

***Handbook of Engineering Fundamentals,** Second Edition, edited by Ovid W. Eshbach, published by John Wiley & Sons, Inc., New York; 1952; 1094 5¼ x 8¼ inch pages; $10.00.

This new version of Eshbach's widely used general engineering handbook differs from the first edition (1936) as follows:

The engineering tables have been enlarged to include standard structural sizes for aluminum, and data on tangents and offsets for civil engineers. The table on standards and symbols has been brought up to date, and the MKS system of units has been incorporated in the tables of conversion factors.

Some of the simpler mathematical items previously introduced for completeness have been eliminated, and greater stress has been placed on statistics, determinants, and vector analysis.

The revision incorporates changes in units and international standards since the first edition and gives greater emphasis to MKS and rationalized MKS systems of units.

The section on mechanics has been divided with reference to anticipated fields of application. The mechanics of rigid bodies is basically Newtonian mechanics and includes statics, kinematics, kinetics, and application to frictional phenomena. A brief discussion of more generalized theory has been added, but complete treatment involving theory of relativity was not attempted. Likewise, the advanced but fundamental theory of elasticity was considered unsuited to a simple, condensed presentation of the mechanics of deformable bodies, which includes mechanics and resistance of materials in a conventional manner. Here, also, the symbols have been changed to those now in common use, and codes of practice now obsolete have been replaced by recommended standards.

The section on fluid mechanics has been divided into two parts and completely rewritten. The first part deals with the mechanics of incompressible fluids with major emphasis on hydraulics; the second deals exclusively with aerodynamics with emphasis on the theory basic to the design and performance of aircraft.

The treatment of thermodynamics is essentially the same. Illustrative examples have been changed or added, and a table of properties of dry air has been included.

The section on electricity and magnetism has been completely revised, the theory being presented in the MKS system of units.

The sections on metallic and non-metallic engineering materials have been completely revised, and much material, more detailed and of value to special groups, has been eliminated to keep the volume within practical size.

The last section, on engineering law, has also been rewritten.

***Die Farbe** is a new German scientific journal dealing with problems of color science such as color vision and its testing, color matching, light and color, evaluation of fastness, color photography, television and reproduction, color psychology and color conditioning, color standardization work and color nomenclature and terminology. Besides original papers there will be published reviewing articles, book reviews, and news about events, persons, and organizations concerned with color problems. Each article will be prefixed by a short abstract in both English and German.

The new publication is edited by Dr. Manfred Richter, Unter den Eichen 87, Berlin-Dahlem. Subscriptions should be addressed to the printer, Verlag für angewandte Wissenschaften GmbH., Rheinstrasse 79, Wiesbaden. Price prepaid is 7.80 marks per issue (9.00 marks for back copies); subscription price is 42 marks per volume of six issues.

To assist and encourage electric company executives in taking advantage of opportunities afforded in the home lighting market **The Home Lighting Story of Company X,** a case study of a "typical" electric company's residential lighting promotion, based on the actual experiences of 18 small and large utilities, has been released by the Edison Electric Institute.

Prepared as a report by the E.E.I. Residential Lighting Committee, the booklet illustrates the operations and practices now in use by electric utilities in developing home lighting, and also how the different promotional methods described could be adapted to any particular company. The areas served by the eighteen companies whose experiences have been drawn upon to make up this composite "Company X" are widely scattered throughout the United States.

Divided under six general headings, Training, Educational Activities, Sales Promotional Activities, Special Campaigns, Results and Conclusions, the new booklet gives a concise step-by-step description of the problems that were encountered and their solutions.

Attractively printed in two colors and illustrated, the 28 page booklet is

(Continued on page 21A)

I.E.S. Regional Conferences, 1953

Canadian	Chateau Laurier Ottawa, Ont.	March 23-24
Southwestern	Hotel Baker Dallas, Tex.	April 12-14
Pacific Northwest	Multnomah Hotel Portland, Ore.	April 23-24
Midwestern	Radisson Hotel Minneapolis, Minn.	April 30 - May 1
East Central	Hotel Lord Baltimore Baltimore, Md.	May 14-15
Southern	Sedgefield Inn Greensboro, N. C.	May 18-19
Great Lakes	Syracuse Hotel Syracuse, N. Y.	May 25-26

BETTER *illumination* FOR AIRPORT RUNWAYS

KOPP ENGINEERED LENS solves critical lighting problem

The value of Kopp's combined engineering and manufacturing skills is vividly demonstrated in the new bi-directional airport runway light lens, illustrated here. To overcome the shortcomings of previous runway lights, specifications were set up that could not be met by any lenses of previous design. In collaboration with Westinghouse engineers, Kopp specialists, through research, experiment and engineering development, produced a lens that fully meets or exceeds all requirements—and at a greatly reduced overall cost.

The skill, knowledge and resourcefulness displayed in developing this airport runway lens is available to anyone seeking the answer to a vexing illumination problem.

If you have a lighting problem that involves lenses or color filters for concentrating or diffusing the beam, or for transmitting any selected portion of the spectrum, Kopp engineers will be glad to help you find the lens pattern and type of glass that will give the results you want.

KOPP GLASS

KOPP GLASS, Inc.
SWISSVALE, PA.

Leader low brightness LENSPANEL*

We take great pleasure in presenting the beautiful new Leader Low-Brightness LENSPANEL of clear, sparkling, lucite plastic . . . another Leader first! A new solution to the problem of enclosing fluorescent fixtures for maximum efficiency in light distribution, low surface-brightness, and better protection from dust and breakage. Leader's LENSPANEL offers not only these advantages, but the plus values of lighter weight, greater beauty and lower cost.

Here is what it is:

Leader's LENSPANEL is a plastic lens with inner surface deeply incised in ⅛" squares, the outer surface completely smooth and free from all irregularities. Plastic is rigid, strong, warp-proof. Weighs only a fraction as much as glass of equal size and thickness.

Here is what it does:

This new lucite lens brings greater beauty to fluorescent lighting . . . offers 45° shielding, with freedom from glare . . . provides greater protection . . . reduces structural strain because of its light weight . . . requires less maintenance.

Leader fixtures on which the new LENSPANEL is now available:

RECESSED TROFFERLITES

T-240-LP

All Leader recessed Trofferlites are now available with LENSPANEL, adding a whole new series to the already versatile trofter system of fluorescent lighting. Lengths from 48" to 96", in 12" or 24" width, furnished for a variety of mounting styles, for from 1 to 8 lamps.

PTE SERIES

PTE-340-LP

Designed especially for efficient and economical store lighting, Leader's PTE is more striking than ever when supplied with the new lucite LENSPANEL. Models for 2, 3 or 4 lamps, either 40-watt or Slimline in lengths from 48" to 96".

*Pat. Pending

Sold and installed by the better electrical wholesalers and contractors

Leader *America's No. 1 Lighting Equipment Manufacturer*

LEADER ELECTRIC COMPANY • 3500 North Kedzie Avenue, Chicago 18, Illinois
Leader Electric—Western: 800 One Hundredth Avenue, Oakland 3, California
Campbell-Leader, Ltd.: Brantford, Ontario, Canada

(Continued from page 18A)

primarily designed for utility executives, and is expected to prove interesting to others in home lighting promotion.

Group Replacement of Fluorescent Lamps, 16-mm sound film, points out the advantages of this system as a money saver and as an efficient method of maintaining good lighting. The color film, which uses a variety of production techniques:— cartoon animation, slide motion, realistic art, studio lip-sync, and location and factory motion picture photography — is being presented by the Lamp Division of Westinghouse Electric Corp. and is being promoted nationally. Eugene W. Beggs, fluorescent and mercury vapor lamp manager in the division's Commercial Engineering Department, and R. F. Townsend, section engineer, were technical advisers on the film.

How Your Community Can Conduct a Christmas Lighting Contest is the subject of a planning guide on procedure for promoting and carrying through these contests. Featured is a case history —the experience of Richmond, Indiana— tracing it step by step from start to finish. Suggestions for contest rules, prizes and selection of judges, publicity instructions, lighting ideas, sample entry blanks and other aids for a contest sponsor are included. Copies of the kit are available to public service companies, civic groups, city officials and others interested by writing the Inquiry Bureau, Lamp Division, General Electric Co., Cleveland 12, Ohio.

NEW MEMBERS

At the meeting of the I.E.S. Council held in New York, N. Y. October 9, 1952, the following were elected to membership:

ARIZONA CHAPTER

Associate Members:

Hughes, Wm. H., Hughes Aircraft Co., Tucson, Ariz.

Ketaily, E. C., Tucson Electric Supply Co., Tucson, Ariz.

CAPITAL SECTION

Member:

Cole, M. W., Engleby Electric Co. Inc., Roanoke, Va.

Associate Member:

Galblum, G. A., Service Electric Supply Corp., Wheaton, Md.

CAROLINAS SECTION

Associate Member:

Paulling, J. M., Sylvania Electric Products Inc., Columbia, S. C.

CENTRAL ILLINOIS CHAPTER

Associate Members:

Brown, J. W., Central Illinois Light Co., Peoria, Ill.

Wooddell, E. B., Larson Electric, Peoria, Ill.

CENTRAL NEW YORK SECTION

Associate Member:

Fabozzi, J. E., Fluorescent Lite & Fixture Co. Inc., Syracuse, N. Y.

CHICAGO SECTION

Member:

Dunbar, M. M., 2450 Winnetka Ave., Glenview, Ill.

CLEVELAND SECTION

Members:

Behan, J. R., Central National Bank, Cleveland, Ohio.

Wheeler, K. L., Cleveland Electric Illuminating Co., Cleveland, Ohio.

Associate Member:

Earley, A. E., General Electric Co., Cleveland, Ohio.

CONNECTICUT SECTION

Member:

Ballard, R. E., Connecticut Light & Power Co., Hartford, Conn.

Associate Members:

Cobb, E. E., Westcott & Mapes, Inc., New Haven, Conn.

Maxwell, O. B., Maxwell Equipment Co., Milford, Conn.

Myers, J. S., Connecticut Light & Power Co., Thompsonville, Conn.

FLORIDA CHAPTER

Associate Members:

Allcorn, R. H., Allcorn Electric Co., St. Petersburg, Fla.

Bailey, Cy., Hughes Supply Co., Inc., Gainesville, Fla.

Freeze, J. M., Olson Electric Co., Daytona Beach, Fla.

Holl, R. C., Hughes Supply Inc., St. Petersburg, Fla.

Mallory, H. I., General Electric Co., Tampa, Fla.

Mattox, W. E., Moe Light, Inc., 3605 Corona St., Tampa, Fla.

Olson, C. W., Jr., Olson Electric Co., Daytona Beach, Fla.

Torres, A. P., Graybar Electric Co., Inc., Tampa, Fla.

Williams, W. T., General Electric Co., Tampa, Fla.

FOREIGN NON SECTION

Associate Members:

Fantz, G., Claude Paz & Silva, Paris, France.

Harada, Tsuneo, Tokyo Shibaura Electric Co., Kawasaki, Kanagawa, Japan.

Student Member:

Ackerman, K. R., British Thomson Houston Co., Rugby, Warwickshire, England.

GEORGIA SECTION

Members:

Fulton, C. G., Fulton Bros. Electric Co., Atlanta, Ga.

Hiller, R. H., Curtis Lighting Inc., Atlanta, Ga.

Sweatte, J. E., Georgia Power Co., Atlanta, Ga.

Associate Members:

Andre, S. J., Georgia Power Co., Atlanta, Ga.

Guy, W. W., 2129 7th Ave., N., Birmingham, Ala.

Johnson, E. D., 303 Bona Allen Bldg., Atlanta, Ga.

Wilson, Jack, Matthews Electric Supply Co., Birmingham, Ala.

HEART OF AMERICA SECTION

Associate Members:

Burwell, M. H., Day-Brite Lighting Co., Kansas City, Mo.

Thompson, N. J., The Kansas Power & Light Co., Lawrence, Kans.

INDIANA SECTION

Associate Members:

Easley, J. R., Westinghouse Electric Supply Co., Indianapolis, Ind.

Marshall, V. E., Revere Electric Mfg. Co., Indianapolis, Ind.

Rowe, A. E., General Electric Co., Ft. Wayne, Ind.

Student Member:

Morales, R. J., Purdue University, Lafayette, Ind.

INLAND EMPIRE CHAPTER

Member:

Crenshaw, D. R., Columbia Electric & Mfg. Co., Spokane, Wash.

Associate Member:

Kuhlman, F. W., Washington Water Power Co., Pullman, Wash.

MARYLAND SECTION

Members:

Gillespie, M. E., Consolidated Gas Electric Light & Power Co., Baltimore, Md.

Hofman, J. A., III, Egli & Gompf Inc., Baltimore, Md.

MEXICO CHAPTER

Associate Member:

Casares-Ponce, A., Cervecería Yucateca S. A., Merida, Yucatan, Mexico.

MICHIGAN SECTION

Member:

Scott, R. N., Smith Hinchman & Grylls, Inc., Detroit, Mich.

MISSISSIPPI CHAPTER

Associate Member:

Haynes, C. P., Watts Electric Co., Jackson, Miss.

NEW ENGLAND SECTION

Member:

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Associate Members:

Bucknam, P. C., General Electric Supply Corp., Boston, Mass.

Chatterton, R. J., Crocker Co., Providence, R. I.

Eaton, S. H., Sylvania Electric Products Inc., Boston, Mass.

Graffum, N. S., Sylvania Electric Products Inc., Ipswich, Mass.

NEW MEXICO CHAPTER

Associate Member:

DeKraker, G. M., Westinghouse Electric Supply Co., Albuquerque, N. M.

NEW ORLEANS SECTION

Associate Member:

Guillot, E. C., Jr., Pere Marquette Bldg., New Orleans, La.

NEW YORK SECTION

Members:

Bachman, H. E., Westinghouse Electric Corp., Bloomfield, N. J.

Brooke, A. H., Benjamin Electric Mfg. Co., New York, N. Y.

Flannery, L. F., 245 Sterling Ave., Orange, N. J.

Heine, T. H., Westinghouse Electric Corp., Bloomfield, N. J.

Jones, J. R., Westinghouse Electric Corp., Bloomfield, N. J.

Kelly, Richard, 148½ E. 40th St., New York, N. Y.

(Continued on page 34A)

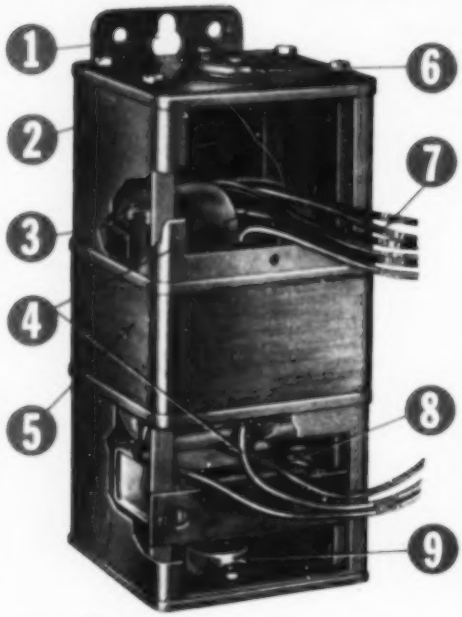
BETTER - *Nine Ways*

FOR INDOOR MERCURY LAMP OPERATION

Only

JEFFERSON

TRANSFORMERS *have ALL these* EXTRA-VALUE FEATURES



1 EASY MOUNTING! Top and bottom brackets have keyhole slots for easy positioning and two holes for locking bolts. Brackets are removable or reversible for messenger wire suspension, etc.

2 PLENTY OF KNOCKOUTS! One half and ¾" knockouts in sides of wiring compartments at each end. Two ½" knockouts in each end plate.

3 DOUBLE VARNISHED CORE AND COIL! Oven baked polymerizing varnish impregnation assures permanent insulation and protection against moisture.

4 INCANDESCENT & MERCURY LAMP LEADS, BOTH ENDS! For fast and convenient wiring of combination mercury vapor and incandescent lamp fixtures. Mercury lamps can also be wired from either end of transformer.

5 PRESS FIT RIVETED CORE! For positive uniformity of manufacture and maximum quality.

6 INTERCHANGEABLE FITTINGS! Pryouts on both ends expose standard ½" conduit fittings for suspension type mounting of transformer and/or lamp. ¾" fittings quickly interchangeable.

7 THREE PRIMARY TAPS! Color-coded tagged leads for positive identification and quick wiring. Three primary taps (not just two) for close matching with line voltage, and maximum lamp and transformer performance.

8 AMPLE WIRING COMPARTMENTS! Condenser located to allow ample wiring space when any knockout is used. Condenser is solidly mounted to prevent damage by vibration to condenser and leads.

9 NO OBSTRUCTIONS! Plenty of room between condenser and conduit fittings to run wiring through lamp suspension conduit. Save time, trouble, and outside wiring. End cover knockouts are **completely** free of obstructions for quicker installations.

You find *all* the extra-values *only* in the newly revised line of Jefferson Transformers. Every feature vital to top-flight service, economy, and ideal lamp performance is built-in to give you unmatched value in every detail.

Get the most out of your mercury lamp installations by insisting on Jefferson Transformers. They operate all H-1 400 watt mercury lamps. Models are available for all indoor and outdoor applications. Underwriters' Laboratories approved.

Write for 16-page illustrated Bulletin 521-5 now.

The Jefferson line also includes the finest transformers for both H-12 and H-15 1000 watt mercury lamps.

JEFFERSON ELECTRIC COMPANY
Bellwood, Illinois

Jefferson Transformers

Chairs or Chocolates...

Crown Furniture Co. Skylike provides an easily-maintained, high-level incandescent lighting system for the Crown Furniture Company's new Detroit store. 100 foot candles were required to overcome the daylight pouring in both glass-walled ends of the showroom, yet individual area intensities may be modified for special effects by simply changing lamp sizes. Floor-level relamping with pole-type changers offers maintenance savings by eliminating the use of ladders or disturbing the floor displays.

SKYLIKE lighting shows off merchandise at its selling best.

Loft Candy Shops — As a part of its progressive modernization program, Loft has specified Skylike units as the primary light source in its stores. Experience showed that incandescent light presented its fine chocolates and other candies in the most appealing manner. Careful tests were made by Loft executives to assure them that Skylike's diffused radiation eliminated the heat problem at the display level. The view at left is of Loft's new White Plains store.

How SKYLIKE blends 2 types of Lighting Units into 1

SKYLIKE systems for stores are flexible and easy to plan. Modular 24" x 24" units can be recessed, semi-recessed, or surface mounted. They require low initial investment, too — cost only ½ to ⅓ as much as other equipment delivering comparable results.

Note these additional SKYLIKE advantages: high-maintained light output; softly diffused shadows; warm color values; instant starting; floor-service re-lamping; variable lamp size (150-to 500-watt).

Try SKYLIKE on your next lighting installation.

1. Soft, indirect light from silvered-bowl incandescent lamps...

2. The modern look of fluorescent-type troffers.

SEND FOR COMPLETE DETAILS

SKYLIKE LIGHTING, INC. — A Silvray-associated company
104 West Main Street, Bound Brook, New Jersey

Gentlemen:

Please send me further information on Skylike lighting.

Name _____

Firm _____

Address _____

City _____ Zone _____ State _____

1927 1952 OUR 25TH YEAR **Silvray** ALWAYS... the best in lighting

HOW G-E EQUIPMENT SAVES YOU MORE ON SERIES STREET-LIGHTING SYSTEMS

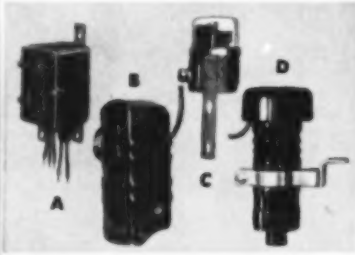
- ***Get optimum lamp performance***
- ***Save costly man hours in servicing . . .***

WITH G-E CONSTANT CURRENT TRANSFORMERS

You reduce operating expenses with G-E Constant Current Transformers because they give exceptionally fine control of secondary current from short circuit to full load . . . assuring maximum lamp life. They compensate instantly for even small changes in load or applied voltage, maintain low starting surge. They're easy to install, maintain their regulation with up to 5 degrees rake, and they're constructed for years of dependable, low-maintenance service.

Illustrated is the Type RO, normal power factor outdoor automatic current-regulating transformer; ratings 5 to 30 kw. Other G-E constant-current transformers: ROC, outdoor, high pf, 5 to 30 kw; RF, station-type, air-cooled, normal pf, 15 to 50 kw.

G-E TYPE RO TRANSFORMER



- ***Protect your circuits***
- ***Reduce operating costs . . .***

WITH G-E CONSTANT CURRENT CONTROL DEVICES

A Type J-1 Protector—provides protection from the hazards of open circuit conditions.

B Fuse Cutout—for primary fault and surge protection.

C Type P-1 Photoelectric Relay—low cost control automatically turns lighting circuits on at dusk, off at dawn.

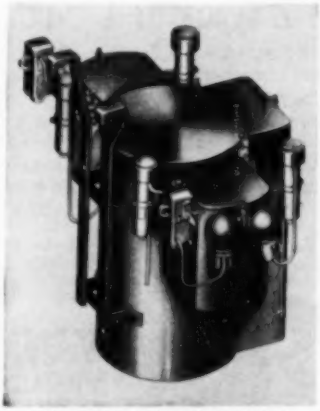
D Pellet Lightning Arrester—for protecting both primary and secondary side of transformers.

E Type E-1 Controller (not shown)—heavy-duty solenoid-operated oil switch to control transformers.

- ***Cut installation time and expense . . .***

WITH G-E "PACKAGED" REGULATORS

You reduce installation time and conserve pole space with G-E "packaged" Substation Type Constant-Current Regulators (illustrated at right). Available in 15, 20, 25, and 30 kw ratings, these "packages" contain all protective and controlling elements for efficient, economical series street-lighting operation where 120 V, 60 cycle control power is available. They are factory assembled and can be put into service simply by connecting power and control leads. Each component is readily accessible for servicing.



G-E SUBSTATION-TYPE REGULATOR

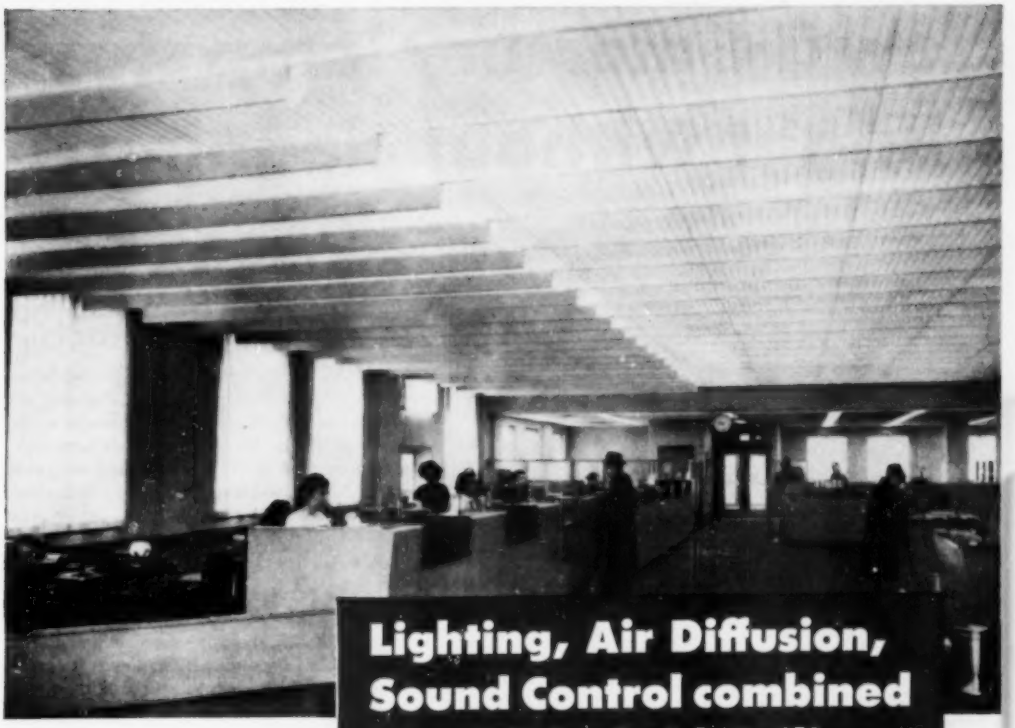
- ***Reduce planning, purchasing costs . . .***

WITH G.E.'s COMPLETE LINE OF EQUIPMENT

You can get all the equipment and devices you need for your series street-lighting systems from G.E.

Moreover, G-E lighting engineers will be glad to help you plan for your street-lighting needs. For information on any of the above equipment, or on G-E engineering service, write *Section 452-131, General Electric Co., Schenectady 5, N. Y.*

GENERAL ELECTRIC



Lighting, Air Diffusion, Sound Control combined in a Wakefield Ceiling

Three environmental factors are controlled simultaneously by this Wakefield Ceiling:

1. From hidden fluorescent lamps, high level, low brightness light is diffused evenly through corrugated Plexiglas diffusers. Brightness contrasts are low; both direct and reflected glare are at a minimum.
2. Conditioned air is delivered into the room through the multiple openings at the edges of the corrugated diffusers. Although each of these spaces has an area of only 1.04 sq. in., their great number presents a large total area for low velocity air movement.
3. Sound is effectively absorbed by Fiberglas-filled perforated metal baffles, suspended from the diffusers.

The Wakefield method of combining efficient lighting, air diffusion and sound control in a luminous ceiling cuts building costs and results in a fixture-free, duct-free, architecturally discreet appearance.

Wakefield Ceilings have been installed in private offices, general offices, drafting rooms, art departments, display rooms, research areas, testing rooms, laboratories, control rooms, stores, auto show rooms and many other areas. *Write for your copy of a 34-page booklet. The F. W. Wakefield Brass Company, Vermilion, Ohio.*

Room Area: 36'4" x 76'8"
Height of datum line: 12'6"
Height of Wakefield Ceiling: 11'0"
Distance Wakefield Ceiling to lamps: 13"
Lamps: T-12 430MA
21 lamps 96"
76 lamps 72"
51 lamps 48"
Average footcandles: 45
Brightness ratios from task to:
Ceiling 1 to 4
Baffles 1 to 1.2
Walls from 1 to 1.1 to 1 to 1.7
Background of seeing task 1 to 2.5
Floor 1 to 1.3
Furniture 1 to 3.3

THE EQUITY SAVINGS ASSOCIATION
Cleveland, Ohio
Architects:
Dalton-Dalton, Associates; Engineers
Cleveland, Ohio
Licensed Installer:
The Parker Electric Company
Cleveland, Ohio
Licensed Agent:
The General Electric Supply Company
Cleveland, Ohio

Wakefield **Over-ALL Lighting**

New G-E mercury lamp stays bright without cleaning!

G-E produces first mercury lamp with built-in reflector

General Electric's new 400-watt mercury lamp for general lighting needs no cleaning or maintenance throughout its life under ordinary use. The first reflector mercury lamp ever made available, the G-E H400-R1 is designed for foundries, welding shops and other plant areas where collection of dirt on fixtures severly cuts light output and high mounting makes cleaning difficult.

Because the reflector is built-in, dust collecting on the sides of the lamp can't reduce light output. The highly efficient reflecting surface controls the diffusion of light, directs it downward through the bottom of the bulb where little or no dust collects. The new H400-R1, shown at left, generates light of the regular mercury color.

New reflector lamp also available in color improved type

The new built-in reflector mercury lamp above is also available in a special color-improved type, the H400-RC1, for plant areas that require lighting with good color rendition. It has all the advantages of the lamp shown above, yet gives better color than regular mercury lamps. A novel application of phosphor to the inside of the bulb produces approximately the same color as a mixture of ⅓ filament light and ⅔ mercury light. This new lamp is available in 400 watts. The H400-R1 and H400-RC1 lamps have a life rating of 3,000 hours at five hours per burning start, and 4,000 at 10 hours per start. Both have mogul screw bases.

1000-watt lamp added to regular G-E mercury line

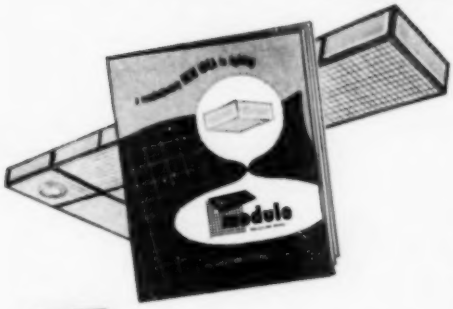
This new G-E lamp fills the gap between the 400-watt and 3000-watt lamps in the regular G-E mercury line. Producing 52 lumens per watt, it is the most efficient of the mercury lamps used for general lighting. Particularly suited for high mounting in industrial areas where low cost of light is desired.

You can put your confidence in —

GENERAL ELECTRIC

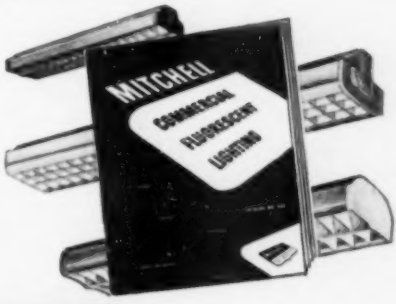
easiest to specify, easiest to install, easiest to sell

America's most **complete** Quality Lighting Line



MITCHELL **module** CUSTOM-FITTING LIGHTING

The revolutionary lighting system for commercial interiors. Forms unlimited patterns—delivers 20% MORE LIGHT—installs quickly and economically—offers enduring beauty. Four basic "building blocks of light" CUSTOM-FIT any commercial interior at no more than the cost of ordinary fixtures. For full details, ask for **Catalogs No. 360 and No. 370.**



MITCHELL **COMMERCIAL FLUORESCENT LIGHTING**

MITCHELL offers 70 superb Commercial Luminaires to meet the requirements of every conceivable installation: stores, offices, schools, institutions. You can specify MITCHELL Luminaires with confidence—they're tops for quality, time-saving installation, low-cost maintenance and lighting efficiency. **Ask for Catalog No. 433.**

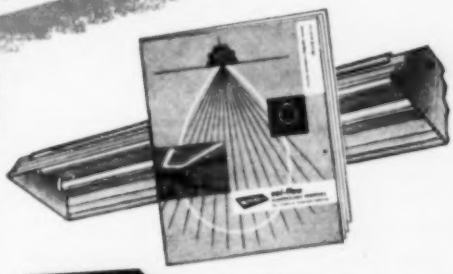
MITCHELL

EVERYTHING IN LIGHTING FROM ONE DEPENDABLE SOURCE

MITCHELL **DYNALITE**

Job-rated Lighting for Industry

You'll find it easy to specify for any industrial application when you choose from the complete line of 82 DYNALITE units. Available in all lengths and lamp types, with choice of reflectors and shielding. There's a DYNALITE that's PRODUCTION-RIGHT for every job. Full details in **Catalog No. 438.**



MITCHELL ***uni-flow***

Fluorescent Recessed Lighting

Here's the latest and finest achievement in recessed lighting: 6 different troffer lengths (shallow or deep); 12 types of shielding; 7 types of lamps; choice of reflectors—PLUS exclusive ONE-MAN installation feature that cuts installing time by 50%! The complete facts are in **Catalog No. 605.**

It's easy to specify, easy to sell from MITCHELL'S "tell-all" Catalogs covering Everything in Lighting. Write for them today.

MITCHELL MANUFACTURING COMPANY
2525 W. Clybourn Ave., Chicago 14, Illinois
In Canada: Mitchell Mfg. Co., Ltd.,
14 Waterman Ave., Toronto

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DEPT. 3-L

Formed PLEXIGLAS Lighting Panels Provide Decorative Appeal at Gateway Center

All lobby corridors of the Gateway Center buildings in Pittsburgh are lighted as shown above, by custom-formed panels of PLEXIGLAS acrylic plastic suspended beneath cold cathode tubes.

The architects wanted a faceted ceiling design that would give sparkling texture to the lighting. The designer achieved this by having multiple pyramids formed into each acrylic plastic panel; mounted wall to wall along the corridors, the panels contribute marked decorative appeal to the lighting installation.

Thermoplastic PLEXIGLAS panels can be formed easily to almost any shape or design. This makes it possible to combine lighting with decorative treatments of ceilings—frequently at substantial cost savings. In addition there are the advantages of diffused illumination, low brightness ratios, and fixture-free appearance.

We will be glad to send you design details of the luminous ceiling shown above.

Gateway Center, Pittsburgh, Pa.—a trio of steel-clad office towers erected by the Equitable Life Assurance Society as part of the city's famed redevelopment program. Approximately 11,000 square feet of PLEXIGLAS diffusing panels are used for luminous ceilings in lobby corridors.

Architects:
Irwin Clavan and Eggers & Higgins, New York

Builder:
Starrett Bros. and Eken, New York

Lighting Design:
Lighting by Feder, New York

PLEXIGLAS Fabrication:
Dura Plastics, Inc., New York

PLEXIGLAS *is a trademark, Reg. U. S. Pat. Off. and other principal countries of the Western Hemisphere.*

Canadian Distributor: *Crystal Glass & Plastics, Ltd., 130 Queen's Quay at Jarvis Street, Toronto, Ontario, Canada.*

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PUBLICATIONS *of the*
ILLUMINATING ENGINEERING SOCIETY

These publications summarize the studies and conclusions of technical committees of the Illuminating Engineering Society over a period of years. They contain the latest available information about many aspects of the art and science of illumination, and include details of application as well as lighting technique. Each publication listed here carries the authority and approval of the Society.

These Society publications are available in single copies for information and for lighting reference book shelves or in quantity for educational or other distribution. Each publication is numbered for ordering when using the coupon printed on the back of this page.

(1) I.E.S. LIGHTING HANDBOOK, Second Edition

BRAND NEW! One volume, 987 pages. Published 1952. Complete revision of first edition includes basic information on all phases of lighting practice and technique, based upon recently developed standards. Contains 18 technical reference and application sections; complete appendices of information regularly used; 655 photos, drawings, lighting tables, charts; fully cross-indexed . . . over 4500 items. For use of lighting engineers and specialists, consultants, architects, designers . . . all who plan, install and manufacture lighting systems and equipment.

$8.00 per copy; $6.40 in lots of ten or more. Add 50c for shipment abroad. *I.E.S. Members are entitled to one copy of the Handbook at $5.50 unless previously ordered.*

I.E.S. RECOMMENDED LIGHTING PRACTICES

These booklets contain the latest official I.E.S. lighting recommendations; illustrated with charts and photographs.

(2) HOME LIGHTING Recommended Practice (1947)

(3) OFFICE LIGHTING Recommended Practice (1947)

(4) STREET AND HIGHWAY LIGHTING American Standard Practice (1947)

(5) LIGHTING PRACTICES FOR STORES AND OTHER MERCHANDISING AREAS (1946)

(6) SCHOOL LIGHTING American Standard Practice (1946)

(7) LIBRARY LIGHTING Recommended Practice (1950)

(8) DAYLIGHTING Recommended Practice (1950)

(9) SPORTS LIGHTING Recommended Practice (1951)

Booklets above available at 50 cents per copy or in quantity as follows: first 4 copies, 50c each; next 20, 25c each; all over 24 copies, 15c each.

(10) INDUSTRIAL LIGHTING American Recommended Practice (1948)

First 10 copies, 25c each; next 40, 20c each; all over 50 copies, 15c each.

REPORTS ON LIGHTING IN INDUSTRY

Lighting recommendations based on recent studies (research, surveys of current practice, and experimental installations) of the I.E.S. Committee on Lighting Study Projects in Industry; completely illustrated. Contain analyses of seeing tasks; recommended quality and quantity of lighting; and suitable lighting methods and systems for both general and supplementary lighting.

(11) LIGHTING FOR WOOLEN AND WORSTED TEXTILE MILLS (1949)
Detailed treatment of lighting for opening and grading, carding, spinning, weaving, and perching. Data is also applicable to other types of textile mills.

(12) LIGHTING FOR MACHINING OF SMALL METAL PARTS (1949)
Analysis of factors affecting visibility of convex scales, steel rules, scribed marks, center-punch marks, concave specular surfaces, plane and convex surfaces; general shop lighting; and supplementary lighting for various measuring instruments, bench work, machine tools, and inspection of polished surfaces.

(13) LIGHTING FOR FLOUR MILLS (1949)
Close-up photos of visual tasks and levels and quality of illumination for roll, sifter and purifier floors; packing areas; and product control stations.

(14) LIGHTING FOR CANNERIES (1950)
Recommendations based on committee study and research on general supplementary artificial lighting and daylighting for tasks common to all types of canneries. Also treated are light sources and equipment suitable for installation in canneries; sanitation and safety; and adequate electrical wiring.

(15) LIGHTING FOR BAKERIES (1950)
Committee study report on baking industry; complete with photos and drawings of typical floor arrangements and lighting layouts; paint color for visual environment; use of day lighting; lighting levels for various departments; maintenance. Also use of ultraviolet.

Booklets (11) to (15) available at 50c each; quantity prices upon request.

OTHER COMMITTEE REPORTS

(16) ART GALLERY LIGHTING (1945)
Completely illustrated guide to lighting exhibits of sculpture and paintings. 50c per copy; quantity prices upon request.

(17) LIGHTING OF CENTRAL STATION PROPERTIES (1951)
Lighting recommendations for control and load dispatch rooms. 50c per copy; quantity prices upon request.

(18) TRANSPORTATION LIGHTING (1951)
Interior lighting for buses, streetcars, rapid transit and railway trains. 25c per copy; quantity prices upon request.

(over)

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1860 Broadway
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Indicate publications wanted by number. Print or type name and address. Clip out and mail.

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64 page report combines recommended residence lighting with good decoration techniques. Report written in laymen's language and is completely illustrated. 130 large scale photographs and drawings show interiors and sketches of construction details using light and color in different home surroundings, Colonial to Modern. Covers both installed luminaires and portables, with separate chapters for cove, recessed, window and wall lighting; ceiling fixtures and wall brackets; portable lamps; use of fluorescent tubes, etc. Available at $1 per copy; quantity prices upon request.

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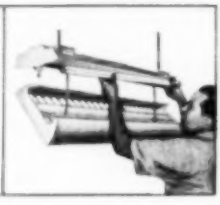

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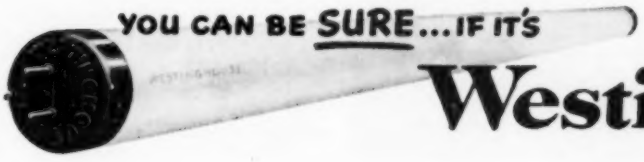

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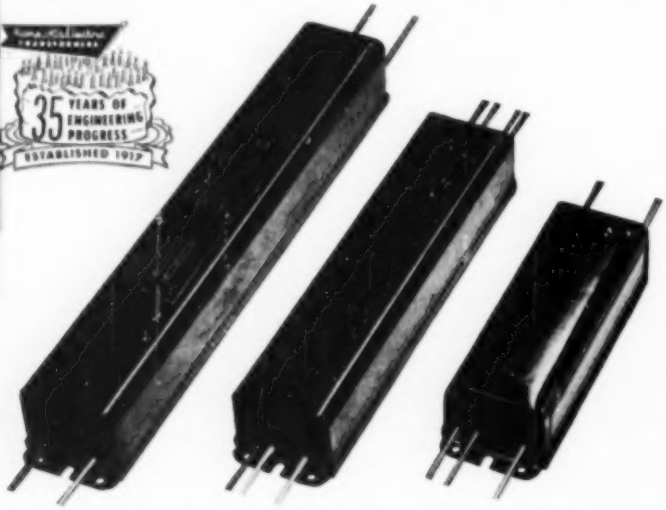

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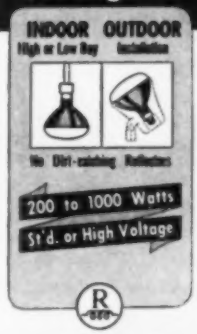

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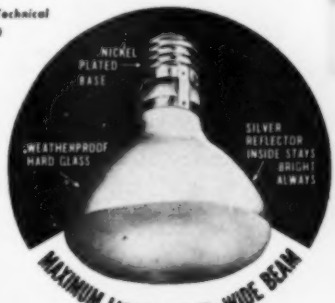
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PROCEEDINGS

containing complete preprints of all technical papers presented at the I.E.S. National Technical Conference, Chicago, Illinois, September 8 through 12, 1952.

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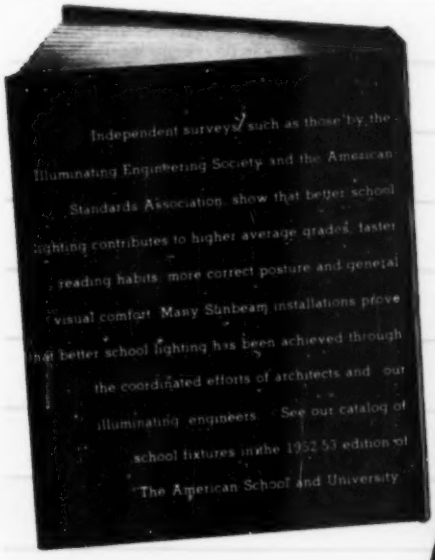
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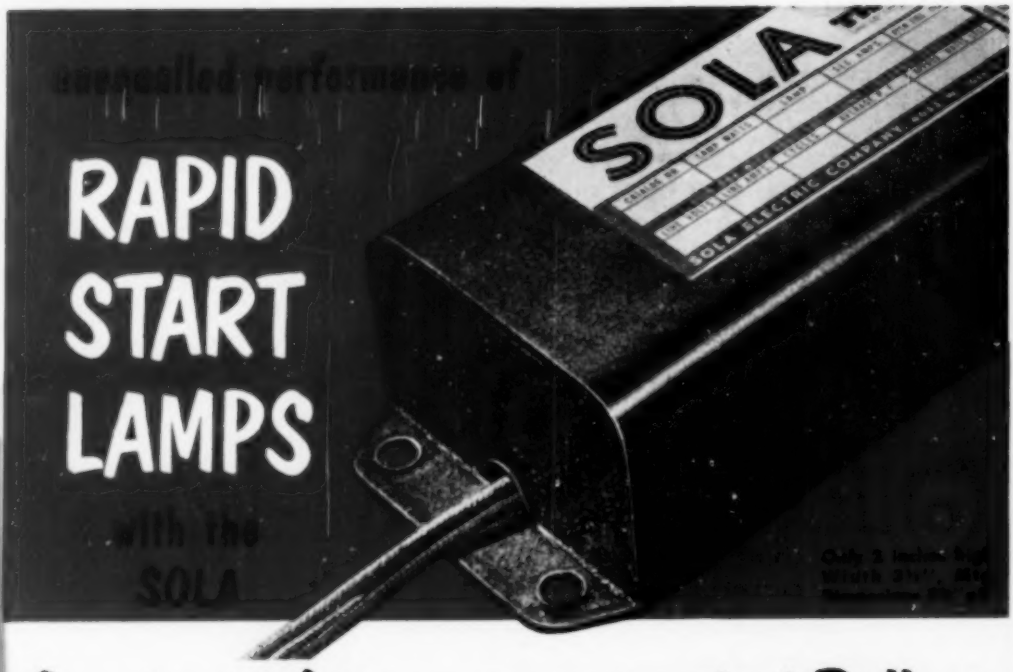

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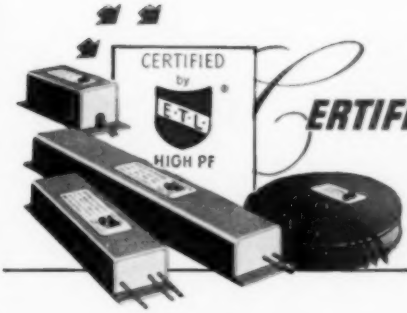

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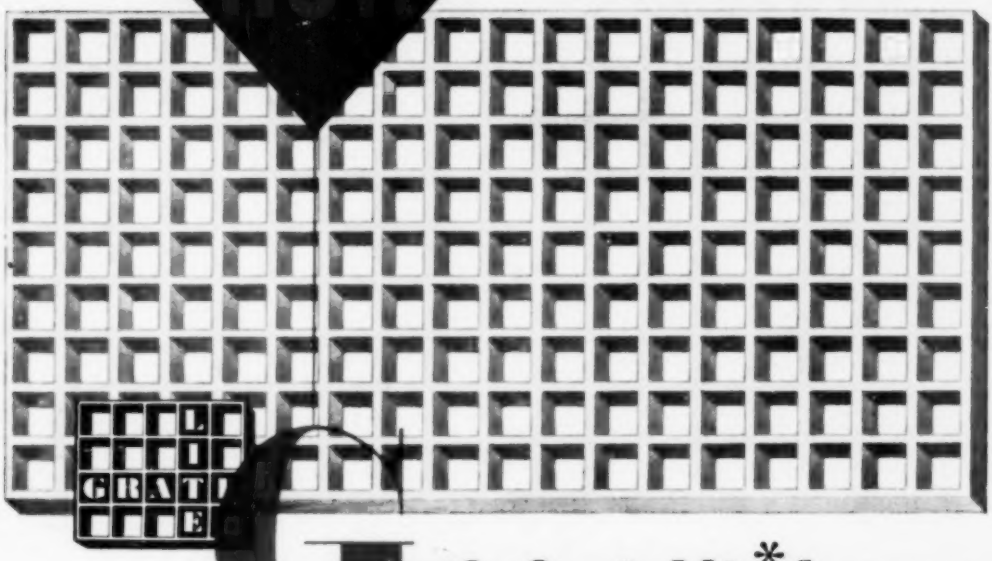

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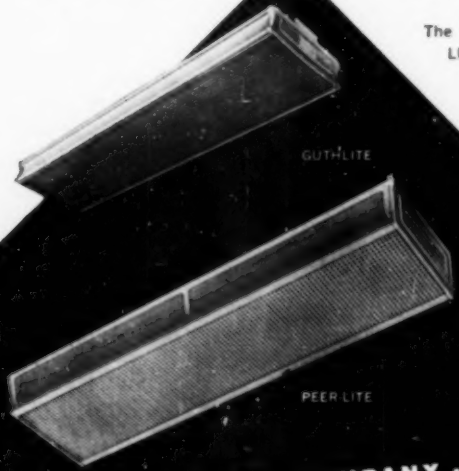

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